ENGINEERING

An Illustrated Weekly Journal

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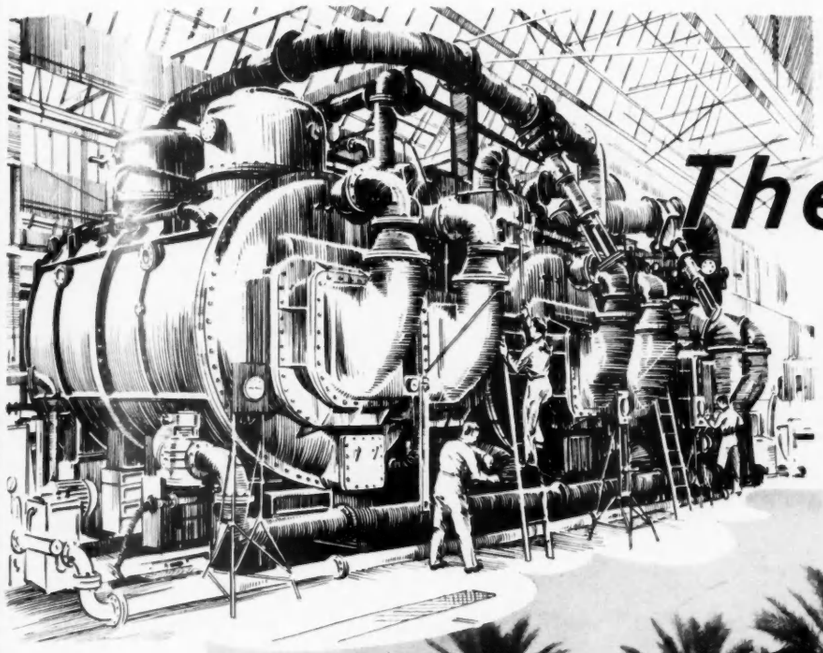

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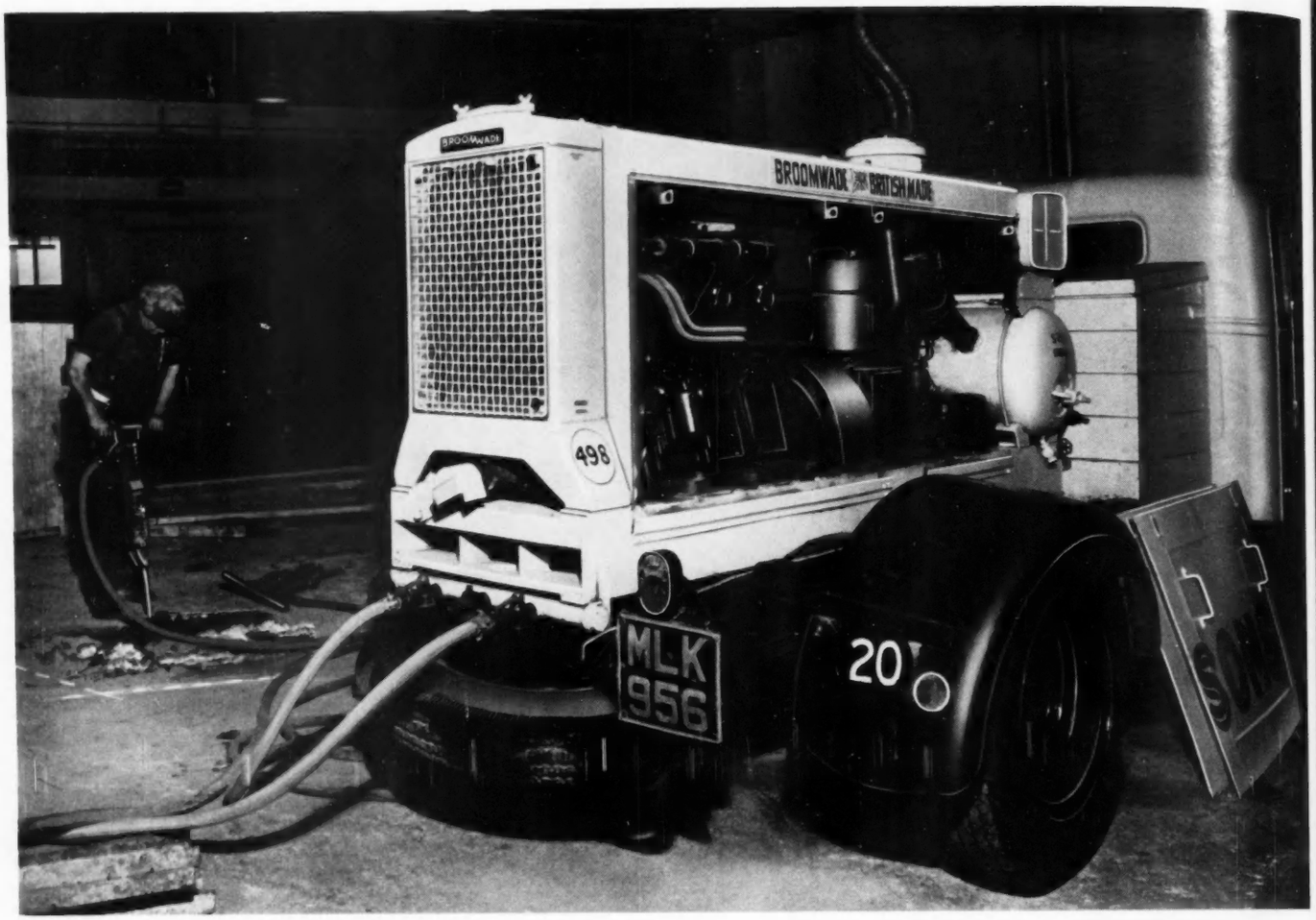

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INDEX TO ADVERTISEMENTS

	PAGE
Asbacas Eng'g. Co., Ltd.	93
Accurate Recording Instrument Co.	17
Adamson, Joseph, & Co., Ltd.	89
Aerospray Assoc., Ltd.	82
Alexander, G. H., Machinery, Ltd.	84
Allspeeds, Ltd.	64
Ardleigh Eng'g., Ltd.	81
Armstrong Stevens & Son, Ltd.	11
Armstrong Whitworth (Metal Industries), Ltd.	32
Associated Lead Manufacturers Export Co., Ltd.	*Wrapper* VII
Atlas Copco A. B.	*Wrapper* V
B.E.N. Patents, Ltd.	12
Barclay, Andrew, Sons & Co., Ltd.	90
Barimar, Ltd.	10
Barry, Henry, & Cook, Ltd.	89
Beecham Buildings, Ltd.	28
Bell, H. (Machine Tools), Ltd.	96
Bird, W. H. & Sons Ltd.	17
Booth, Joseph, & Bros.	66
Borg & Beck Co. Ltd.	*Wrapper* II
Bramigk & Co., Ltd.	68
British Constructional Steelwork Assoc.	59
British Ermeto Corp. Ltd.	16
British Insulated Callender's Cables, Ltd.	38
British 'Rema' Manfng. Co., Ltd.	14
British Ropeway Eng'g. Co., Ltd.	12
British Steam Specialties, Ltd.	86
British Thermostat Co., Ltd.	72
British Thomson-Houston Co., Ltd.	45
Broadbent, R., & Son, Ltd.	84
Broom & Wade, Ltd.	*Wrapper* IV
Brown, E. G., & Co., Ltd.	86
Brown, J., Land Boilers, Ltd.	31
Brown, Lenox & Co., Ltd.	42
Butterley Co., Ltd.	70
Camerer Cuss	91
Carruthers, J. H., & Co., Ltd.	73
Chapman & Hall, Ltd.	4
Clyde Blowers, Ltd.	9
Clyde Crane & Booth, Ltd.	66
Clyde Crane & Eng'g. Co.	66
Conveyor & Elevator Co. (1936), Ltd.	10
Crofts (Engineers), Ltd.	47
Dawson & Downie, Ltd.	86
Delta Metal Co., Ltd.	85
Doncaster, D., & Sons, Ltd.	36
Doxford, Wm. & Sons, Ltd.	14
Duckham, A., & Co., Ltd.	65
E.M.I. Electronics, Ltd.	80
Edwards, F. J., Ltd.	96
Electric Construction Co., Ltd.	39
English Electric Co., Ltd.	46
Farrar Boilerworks, Ltd.	85
Fibreglass, Ltd.	35
Firth Brown Tools, Ltd.	87
Flexo Plywood Industries, Ltd.	58
Fordsmith, H., Ltd.	1
Fraser & Chalmers Engineering Works	43
Galloway, Geo., & Co., Ltd.	84
Glasgow Herald Annual Trade Review	18
Goodall, Clayton & Co., Ltd.	1
Gordon & Gotch, Ltd.	84
Grafton Cranes, Ltd.	18
Greening, N., & Sons, Ltd.	86
Halesowen Steel Co. Ltd.	10
Hall, J. & E., Ltd.	44
Harvey, G. A., & Co. (London), Ltd.	74
Hayes Engineers (Leeds), Ltd.	79
Head, Wrightson Machine Co., Ltd.	20
Heap, J., & Co., Ltd.	41
Heather Filters, Ltd.	14
Henley's, W.T., Telegraph Works Co., Ltd.	87
Herbert, Alfred, Ltd.	88
Higgs Motors, Ltd.	30
Hillman, J. & A., Ltd.	15
Hudswell, Clarke & Co., Ltd.	89
Hughes Bolckow Shipbreaking Co. Ltd.	94
Hughes & Lancaster, Ltd.	82
Igranic Electric Co., Ltd.	85
Imperial Chemical Industries, Ltd.	50 & 53
Jenkins, Robt., & Co., Ltd.	24
Johnson & Phillips, Ltd.	56
Keith Blackman, Ltd.	21
Kitchen & Wade, Ltd.	15
Korting Bros. (1917), Ltd.	88
Lanarkshire Bolt & Rivet Co., Ltd.	13
Lancaster & Tonge, Ltd.	80
Leeds Eng'g. & Hydraulic Co., Ltd.	88
Levy, B., & Co.	89
Lionweld, Ltd.	92
Lloyd & Ross, Ltd.	12
Low, D., Ltd.	93
McAra, A.	78
McGraw-Hill Publishing Co., Ltd.	3
McNeil, C., Ltd.	78
Marshall, Sons & Co. Ltd.	27
Massey, B. & S., Ltd.	40
Matterson, Ltd.	80
Mavor & Coulson, Ltd.	26
Measurement, Ltd.	55
Mek-Elek Eng'g., Ltd.	85
Metropolitan - Vickers Electrical Co., Ltd.	48 & *Wrapper* VIII
Morgan Crucible Co., Ltd.	40
Mulberry Co.	95
National Plastics (Sales), Ltd.	19
Neill, J., & Co. (Sheffield), Ltd.	95
Newage (Manchester), Ltd.	60
Newalls Insulation Co., Ltd.	22
Newbury Diesel Co., Ltd.	88
Nicol & Andrew, Ltd.	9
Norris Bros.	2
Owl Eng'g. Supplies, Ltd.	79
Parker Foundry (1929), Ltd.	54
Parsons, C. A., & Co., Ltd.	*Wrapper* VI
Peckett & Sons, Ltd.	41
Pegler & Louden, Ltd.	91
Plessey Co., Ltd.	39
Positive Lock Washer Co., Ltd.	10
Power Petroleum Co., Ltd.	25
Priest Furnaces, Ltd.	88
Pulsometer Eng'g. Co., Ltd.	57
Quasi-Arc, Ltd.	71
Radiovisor Parent, Ltd.	13
Ransome & Marles Bearing Co., Ltd.	51
Ransomes, Sims & Jefferies, Ltd.	90
Reavell & Co., Ltd.	16
Regent Oil Co., Ltd.	63
Renold Chains, Ltd.	17 & 75
Research Engineers, Ltd.	2
Reyrolle, A., & Co., Ltd.	76
Rocol, Ltd.	90
Rose, Downs & Thompson, Ltd.	23
Rubery Owen Kepston, Ltd.	19
Rushton, Edward, Son & Kenyon	96
St. George's Engineers, Ltd.	11
Salter, G., & Co., Ltd.	69
Savery, T., Pumps, Ltd.	21
Schiess Akt.	37
Serck, H. O., Ltd.	11
Shaw-Petrie, Ltd.	67
Sheffield Twist Drill & Steel Co., Ltd.	18
Silvertown Rubber Co. Ltd.	84
Simmonds Aerocessories, Ltd.	52
Soag Machine Tools, Ltd.	96
Spon, E., & F. N., Ltd.	5
Steel, J. M., & Co., Ltd.	91
Steel Construction Coy., Ltd.	20
Steels Eng'g. Products, Ltd.	77
Stone, J., & Co. (Charlton), Ltd.	34
Stream-Line Filters, Ltd.	13
Swales, C. A. (Filters), Ltd.	9
Talbot, S. (Engineers), Ltd.	23
Tangyes, Ltd.	15
Taylor & Challen, Ltd.	22
Taylor & Hubbard, Ltd.	16
Telco, Ltd.	89
Thermic Equipment & Eng'g. Co., Ltd.	89
United Kingdom Atomic Energy Authority	91
United Steel Companies, Ltd.	33
Vokes, Ltd.	61
Wakefield - Dick Industrial Oils, Ltd.	49
Ward, Thos. W., Ltd.	62, 88 & 96
Weir, G. & J., Ltd.	*Wrapper* III
Wellman Bibby Co., Ltd.	11
Wellman Smith Owen Eng'g. Corpn., Ltd.	83
Wheway, Job & Son Ltd.	81
Wickman, Ltd.	29
Wigglesworth, F., & Co., Ltd.	87
Wolf Electric Tools, Ltd.	19
Wolverhampton Die Casting Co., Ltd.	83
Workington Iron & Steel Co.	33
Zephair, Ltd.	81

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B

CLASSIFIED ADVERTISEMENTS SECTION.

For all advertisements classified under the headings of Tenders, Appointments Open, Situations Wanted, Patent Agents, Partnerships, Wanted, &c., Auction Sales, Publications For Sale, Miscellaneous and Public Notices, &c., the charge will be 12s. for the first four lines or under and 3s. per line up to one inch. When an advertisement measures an inch or more, the charge will be at the rate of 36s. per inch. 5% allowed on 6, 10% on 13, 15% on 26 and 20% on 52 Weekly insertions. If use is made of a box number the extra charge is 2s. per insertion with the exception of advertisements appearing under Situations Wanted. Prospectuses and Notices of Company Meetings £25 per column. Copy instructions must be in our hands first post Monday for the following Friday's issue. Address to the Manager, ENGINEERING LTD., 35 and 36, Bedford St., Strand, W.C.2. Inclusion of advertisements must be dependent on space being available.

PUBLIC NOTICE.

LONDON COUNTY COUNCIL.

ROBERT BLAIR FELLOWSHIP IN APPLIED SCIENCE AND TECHNOLOGY.

Applications are invited for the award of the Robert Blair Fellowship tenable for one year of advanced study or research abroad in applied science and technology. The value of the award is subject to variation, and, if the country selected should be Canada or the U.S.A. may be £2,000, subject to income tax.

Candidates must be British subjects and at least 21 years of age. Further particulars and application forms may be obtained from the EDUCATION OFFICER (EO.WA/14), THE COUNTY HALL, S.E.1, (s.a.e. f'scap), for return by 1st March, 1956. (92). K 72

EDUCATIONAL.

FREE. Brochure giving details of courses in Mechanical and Production Engineering, Draughtsmanship, etc., for the A.M.I.Mech.E., A.M.I.P.E., City and Guilds and other Professional examinations. **E.M.I. INSTITUTES**, DEPT. EG. 30, LONDON, W.4. (ASSOCIATED WITH H.M.V.). G 619

CONSULTANTS.

TEAM OF DESIGNERS available for Mechanical and Production Engineering Special Machines and Projects. NORRIS BROTHERS, LTD., 53, Victoria Street, London, S.W.1. Tel.: Abbey 5444. G 530

TENDERS.

GOVERNMENT OF IRAQ.

DEVELOPMENT BOARD AND MINISTRY OF DEVELOPMENT.

NASIRIYAH ROAD BRIDGE CONTRACT B/8 (1956)

THE DEVELOPMENT BOARD AND MINISTRY OF DEVELOPMENT invites **TENDERS** from experienced Civil Engineering Contractors for the construction of a **STEEL CANTILEVER ROAD BRIDGE** approximately 180 metres long and 11 metres wide over the River Euphrates at Nasiriyah, together with the **STEEL AND REINFORCED CONCRETE APPROACH VIADUCTS** and embankments thereto.

The Contract Documents and Conditions as to Tendering may be inspected on and after the 17th day of January, 1956, at any of the following places:—

(*a*) The offices of the DIRECTORATE GENERAL OF LEGAL AFFAIRS AND CONTRACTS, MINISTRY OF DEVELOPMENT, BAGHDAD, IRAQ.

(*b*) THE EMBASSIES AND LEGATIONS OF IRAQ IN WASHINGTON, PARIS, ROME, BRUSSELS, BONN, CAIRO, KARACHI AND NEW DELHI.

(*c*) The offices of RENDEL, PALMER & TRITTON, 125, VICTORIA STREET, LONDON, S.W.1, ENGLAND.

Firms desiring to Tender may obtain two copies of the Contract Documents between the 17th day of January, 1956, and the 17th day of March, 1956 (both days inclusive) from the DIRECTORATE GENERAL OF LEGAL AFFAIRS AND CONTRACTS, MINISTRY OF DEVELOPMENT IN BAGHDAD, or the offices of RENDEL, PALMER & TRITTON IN LONDON, upon payment of twenty-five Iraqi Dinars or the equivalent thereof for each two sets of documents.

Tenders must be accompanied by a deposit of I.D. 10,000/- (Ten thousand Iraqi Dinars) either in cash or by a letter of guarantee to be made by or through an approved Bank established in Iraq. Fully detailed conditions as to this deposit may be ascertained from the "Conditions of Tender" attached to the Contract Documents.

Tenders must be submitted to the DEVELOPMENT BOARD (DIRECTORATE GENERAL OF LEGAL AFFAIRS AND CONTRACTS, MINISTRY OF DEVELOPMENT), BAGHDAD, IRAQ, in sealed envelopes endorsed clearly on the outside with the words "NASIRIYAH ROAD BRIDGE," and will be received up to noon on the 17th day of April, 1956.

A Memorandum of Capacity, Method of Procedure and Articles of Association must be submitted at the same time.

Particular attention is drawn to Clause 8 of the "Conditions of Tender" stating that tenders will be accepted only from firms of Contractors who have previously executed works of a similar character and magnitude.

Tenders not submitted within the time specified or not accompanied by a receipt of the deposit, or a letter of guarantee or if the Tenderer resides in a Liwa in Iraq where a Chamber of Commerce exists, by a Certificate of Membership of a Chamber of Commerce, shall be neglected.

The Board does not bind itself to accept the lowest or any Tender.

MINISTER OF DEVELOPMENT. J 737

METROPOLITAN WATER BOARD.

TENDERS FOR THE SUPPLY OF STORES, ETC.

TENDERS are invited for the supply of the following stores and services for the period of 12 months commencing 1st April, 1956.

Contract No.

1. **FIREBRICKS, FLETTON, STOCK AND ENGINEERING BRICKS, CONCRETE SLABS, EARTHENWARE BASES AND COVERS, CEMENT AND TARMACADAM.**
2. **BRUSHES, BROOMS AND HANDLES.**
3. **CAST AND SPUN IRON STRAIGHT PIPES, CAST IRON SPECIALS.**
4. **UNIFORM AND MACHANICS' CLOTHING, CAPS, BOOTS, ETC.**
5. **COTTON WASTE, CLEANING CLOTH, HEMP, TARPAULINS, ETC.**
8. **MILD STEEL BARS, PLATES, SHEETS, ETC.**
9. **BOLTS AND NUTS, SCREWS, FILES, STEEL TUBES, SHOVELS, ETC.**
10. **LEAD PIPE AND SOLDER.**
11. **FUEL OIL, KEROSENE AND MOTOR SPIRIT.**
13. **SOAP, METAL POLISH, OILMAN'S SUNDRIES, ETC.**
14. **RUBBER INSERTION AND SHEET ETC., SUCTION, DELIVERY AND CHEMICAL HOSE, CANVAS FIRE HOSE AND RUBBER LINED HOSE.**
19. **SMALL IRON CASTINGS, VALVE, BOXES, HYDRANT BOXES, STOPCOCK BOXES AND NON-FERROUS CASTINGS.**
20. **STOPCOCKS, FERRULE STOPCOCKS, UNIONS, DISC FITTINGS AND GUNMETAL OUTLETS FOR HYDRANTS.**
21. **SLUICE VALVES AND SPINDLES, FIRE HYDRANTS, FLANGED SOCKETS, FLANGED SPIGOTS AND HYDRANT INDICATOR PLATES.**
23. **THE PERIODICAL INSPECTION, REPAIR AND MAINTENANCE OF WEIGHING APPARATUS.**
24. **ELECTRIC LAMPS AND FLUORESCENT TUBES.**
26. **THE REMOVAL OF FURNACE REFUSE.**
27. **PHOTO PRINTS, ETC.**

Tenders must be submitted on the official forms which may be obtained from the Chief Engineer by personal application at the offices of the Board (Room 171) or upon forwarding a stamped addressed envelope (not smaller than 15 in. by 10 in.).

Applicants should refer to the number of the contract for which tender forms are required.

Tenders, enclosed in sealed envelopes, addressed to the UNDERSIGNED, and endorsed in the manner indicated in the form of tender, must be delivered at the offices of the Board (Room 122) not later than 12 noon, Thursday, 9th February, 1956.

The Board do not bind themselves to accept the lowest or any tender.

S. D. ASKEW,
CLERK OF THE BOARD.
OFFICES OF THE BOARD, NEW RIVER HEAD, ROSEBERY AVENUE, LONDON, E.C.1. J 980

LECTURES.

THE COLLEGE OF AERONAUTICS.

A course of lectures on
"COMPRESSIBILITY EFFECTS IN AERODYNAMICS."
will be given at the College from
Monday, 27th February to Friday, 9th March, 1956.

The course will cover both subsonic and supersonic flow and is designed to meet the needs of members of the aircraft industry or research establishments who wish to acquire a grounding in the subject and a guide to recent developments. Particular attention will be paid to problems of flight at high speeds.

FEES for the course are

Tuition Fee	£21
Residence Charge (including full board) ...	£14

COPIES of the SYLLABUS and Forms of Enrolment can be obtained from the WARDEN, THE COLLEGE OF AERONAUTICS, CRANFIELD, BLETCHLEY, BUCKS. J 959

EXPERIMENTAL WORK.

RESEARCH ENGINEERS LIMITED,

Northampton Grove, Canonbury, London, N.1. Canonbury 4244/5/6. We have over 25 years' experience of experimental work and prototypes. We design, develop and manufacture special purpose and labour saving machines, all at the above address. Our range is from the smallest scientific instruments to 3- or 4-ton machines. After a prototype machine has been made and found satisfactory we can manufacture as many as are required in our Works. G 656

PUBLIC APPOINTMENTS.

ADMIRALTY.
ROYAL NAVAL SCIENTIFIC SERVICE.

ENGINEERS AND PHYSICISTS (PARTICULARLY WITH ELECTRONICS) required in Experimental Officer and Assistant Experimental Officer grades in Experimental Establishments in London, Portsmouth, Weymouth areas, Gloucestershire and Scotland. Qualifications: British subjects, minimum of H.S.C. (Pass degree, H.N.C. or near equivalent an advantage). London salary (men), E.O. £790-£960, A.E.O. £320 10s.-£700 (according to age). Appointments unestablished but opportunities to compete for established posts.—Application forms from M.L.N.S., TECHNICAL AND SCIENTIFIC REGISTER (K), 26, KING STREET, LONDON, S.W.1, quoting A214/5A. J 724

DEE AND CLWYD RIVER BOARD.

DEPUTY ENGINEER.

APPLICATIONS are invited from suitably qualified Engineers for the post of Deputy Engineer to the Board at a commencing salary of £1250 per annum rising by two annual increments of £75 each and a final increment of £100 to a maximum of £1500 per annum.

The post is permanent, superannuable, subject to medical examination, and terminable by one month's notice on either side.

Forms of application may be obtained from the undersigned to whom they should be returned when completed so as to reach him not later than the first post on Saturday, the 4th February, 1956.

G. A. WRIGHT,
Executive Officer and Clerk.
45, Nicholas Street,
Chester. J 950

PRESTON.

HARRIS INSTITUTE TECHNICAL COLLEGE.

Applications are invited for the post of **ASSISTANT LECTURER IN ENGINEERING.**

Candidates should be graduates or otherwise qualified and experienced to teach up to the level of the Ordinary National Certificate.

The Salary will be in accordance with the Burnham Scale, Grade B, £525 to £820 p.a., with appropriate allowance for experience, etc.

Forms of application may be obtained from the undersigned, TECHNICAL COLLEGE, CORPORATION STREET, PRESTON, to whom they should be returned within 14 days from the appearance of this advertisement.

H. WILKINSON,
Principal and Secretary. J 946

CITY OF LIVERPOOL.

CITY ENGINEER AND SURVEYOR'S DEPARTMENT.

Applications are invited for the appointment of **DESIGNER DRAUGHTSMAN** (Mechanical Engineering Section). Salary, £690-£840 p.a. (N.J.C. Scale).

Applicants should possess a Higher National Certificate in Mechanical Engineering and have had a recognised practical training in general mechanical engineering, which must include at least 4 years' drawing office practice. Some knowledge of automobile engineering is desirable.

Application forms, obtainable from the City Engineer and Surveyor, Municipal Buildings, Liverpool, 2, should be returned to him by 28th January, 1956.

The appointment is superannuable and subject to the Standing Orders of the City Council. Canvassing disqualifies.

THOMAS ALKER,
TOWN CLERK. J 935

ENGINEERING DRAUGHTSMEN required. Salary £443 to £695 according to age and experience. Prospects promotion and permanency. Should have O.N.C. or equivalent, three years training and drawing office experience on lighting and power or heating and ventilation. Full details to MINISTRY OF WORKS (R.D.1), BROOKLANDS AVENUE, CAMBRIDGE. K 17

SCIENTIST

required in N.C.B's Field Investigation Group which applies the principles of OPERATIONAL RESEARCH to problems of coal production. Good hons. degree in Eng., some post-graduate research or industrial experience and ability to write reports required. Experience of operational research an advantage. Appointment (superannuable), according to qualifications and experience as either SCIENTIST 2 (within inclusive scale £991 to £1360 male) or SCIENTIST 3 (within inclusive scale £617 to £1124 male).

Write, with full particulars of age, qualifications and experience to NATIONAL COAL BOARD, STAFF DEPT. (PERSONNEL), HOBART HOUSE, GROSVENOR PLACE, LONDON, MARKING ENVELOPE SS/179, before 11th FEBRUARY, 1956. K 58

THE UNIVERSITY OF LIVERPOOL.

Applications are invited for the following **FELLOWSHIPS:**—

(i) **IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWSHIPS** in Physics, Chemistry, Engineering, Metallurgy and Pharmacology, or any related subject, to which some appointments may be made during the current academic year. The Appointments will date from 1st October, 1956. The salary will depend upon qualifications and experience, but will normally be within the range £600-£900 per annum, together with F.S.S.U. benefits and family allowances.

(ii) **THREE LEVERHULME POST-GRADUATE FELLOWSHIPS,** two in the Faculty of Science and one in the Faculty of Engineering, tenable for one year at a value of £500, renewable for a second year at a value of £550.

(iii) **RESEARCH FELLOWSHIPS IN NUCLEAR PHYSICS,** tenable for one year, emolument within the range £500-£800 per annum.

Applications, three copies, stating the Fellowship applied for, age, details of qualifications and experience, publications, research work in progress and completed and an outline of the proposed field of research, together with the names of two referees, should be received not later than 1 March, 1956, by the undersigned, from whom further particulars may be obtained. (Candidates overseas who find it more convenient to do so may send one copy only by air-mail).

STANLEY DUMBELL,
REGISTRAR. J 964

GOLD COAST LOCAL CIVIL SERVICE.

AGRICULTURAL ENGINEERS,
DEPARTMENT OF AGRICULTURE,
(GOLD COAST).

Vacancies exist for **AGRICULTURAL ENGINEERS,** Department of Agriculture in the Local Civil Service of the Gold Coast.

Duties include the planning and administration of investigation into problems of agricultural mechanization, the supervision of the maintenance of plant and machinery, advising on agricultural engineering matters and problems and responsibility for implementing approved policy.

Appointment is on contract, for two tours of 18-24 months, in the salary scale—£1130 to £2020 per annum point of entry depending on experience. A gratuity of £12 10s., is payable for each completed month of satisfactory service. Free passages are provided for the officer, his wife, and up to three children under 13 years of age. Government quarters are provided if available, at a rental of £60-£90 per annum. Leave at the rate of 7 days per month of resident service.

Candidates should be not less than 23 years of age and should either have an Engineering Degree or Diploma carrying exemption from Sections A and B of the examinations of the Institution of Mechanical Engineers with two years subsequent experience preferably including work on Agricultural Machinery, or have passed the Institutions examinations, or have an M.Sc. degree in Agricultural Engineering.

Apply in writing to the DIRECTOR OF RECRUITMENT, COLONIAL OFFICE, GREAT SMITH STREET, LONDON, S.W.1, giving briefly age, qualifications and experience. Mention the reference number (BCD 63/13/019). J 957

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY,
ALDERMASTON, BERKSHIRE.
requires

TECHNICIANS.

To assist engineers in the development of airborne electrical and electronic equipment to meet production and service requirements. Applicants should have served a recognised apprenticeship in electrical or mechanical engineering. Possession of O.N.C. or equivalent qualifications in electrical or mechanical engineering is desirable. Applicants should have experience in the handling of difficulties associated with the early stages of small quantity manufacture. Experience with electrical or electronic equipment for use in missiles would be an advantage, and candidates will be expected to be acquainted with up-to-date manufacturing techniques.

SALARY: £608 to £748 p.a. Contributory Superannuation Scheme. Married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates or alternatively assistance towards legal expenses incurred in house purchase will be available; until housed a lodging allowance may be payable.

Requests for application forms by POSTCARD to SENIOR RECRUITMENT OFFICER at the above address, quote reference 874/26. K 9

NOTTINGHAM & DISTRICT TECHNICAL COLLEGE.

PRINCIPAL: D. A. R. CLARK, M.Sc.(Tech.)

Applications are invited for the post of **ASSISTANT GRADE A** to teach Workshop Practice and allied subjects.

Salary: £450 by £25 to £725 per annum, with increments for approved training and industrial experience.

Further particulars and form of application may be obtained from the REGISTRAR, NOTTINGHAM AND DISTRICT TECHNICAL COLLEGE, SHAKESPEARE STREET, NOTTINGHAM, to whom completed forms should be returned not later than 31st January. J 958

F. STEPHENSON,
CLERK TO THE JOINT EDUCATION COMMITTEE.

LONDON COUNTY COUNCIL.

CHIEF ENGINEER'S DEPARTMENT.

RESIDENT ENGINEER.

Applications invited for appointment of **RESIDENT ENGINEER** to supervise construction of sludge digestion plant at Northern Outfall Works, Beckton, E.6. The work will comprise casting and driving reinforced concrete piles, construction of 16 digestion tanks and 4 dewatering tanks in reinforced concrete, together with mains, buildings and incidental works. Applicants should be qualified Engineers with extensive experience in construction of similar works and capable of directing considerable site staff. The appointment is likely to be for a period of not less than 3 years. Salary £1500-£1600 a year according to experience. Application form from CHIEF ENGINEER (56/3), LONDON COUNTY COUNCIL, COUNTY HALL, S.E.1. (25). J 963

CENTRAL ELECTRICITY AUTHORITY,
LONDON DIVISION.

GENERAL ASSISTANT ENGINEERS required for duties in Power Stations in the London Division. Training opportunities available in Power Station work for applicants without previous experience. Candidates should have good engineering education with the minimum qualification of O.N.C. or equivalent. Conditions of employment in accordance with N.J.B. Agreement and salary, within Class AX/EX, Grade 7, £500 to £661 10s. p.a., including London Allowance. Superannuation. Applications may be made on form available from DIVISIONAL SECRETARY, CENTRAL ELECTRICITY AUTHORITY, LONDON DIVISION, P.O. BOX 136, GENERATION HOUSE, GREAT PORTLAND STREET, W.1. Please quote Vacancy No. 5634. K 32

MAINTENANCE ENGINEER required in N.C.B's Headquarters Production Engineering Branch located at Stanhope Brethy, Burton-on-Trent, to advise on systems of planned maintenance and allied matters. Wide experience of this work with an Engineering degree or equivalent, required. Corporate membership of Inst. of Mech. or Elect. Engineers, desirable. Salary, according to qualifications and experience, within range £1122 to £1650. Write, with full particulars of age, education, qualifications and experience to NATIONAL COAL BOARD, STAFF DEPT. (PERSONNEL), HOBART HOUSE, GROSVENOR PLACE, S.W.1, MARKING ENVELOPE SS/175, before 9th February, 1956. J 988

ENGINEER OR CHEMIST (MAIN GRADE) required by the ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKS., to lead a design team responsible for Chemical Plant including Pressure Vessels, Heat Exchangers, Pumps, Fans and Piping Layouts. Applicants should have either:—

(A) CHEMIST—A degree in Chemical Engineering together with four years practical experience of which at least one must have been on plant operation.

or

(B) ENGINEER—A recognised engineering apprenticeship with Corporate Membership of the Institution of Mechanical Engineers or exempting qualifications. They must have been employed in the Chemical or allied Industries and have had considerable experience of the design of the equipment described above.

A knowledge of instrumentation would be considered an advantage.

SALARY:—£1130 to £1435 p.a. Contributory Superannuation scheme. Married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates; alternatively assistance towards legal expenses incurred in house purchase may be payable.

Requests for application forms by POSTCARD to the SENIOR RECRUITMENT OFFICER, at the above address. Quote reference 877/26. J 966

LONDON TRANSPORT
require
DRAUGHTSMEN for Chiswick Works.

Qualifications:—preferably some experience of bus, body and chassis work; previous drawing experience; ability to produce detail and assembly drawings from instructions; apprenticeship and ordinary or higher national certificates advantageous. Salary range £320-£660, with additional payments for certain recognised qualifications. Medical exam.; contributory superannuation scheme after probation; free travel. Applications to RECRUITMENT & TRAINING OFFICER, (F/EV 559) LONDON TRANSPORT, 55, BROADWAY, S.W.1. For acknowledgement enclose addressed envelope. J 981

LONDON COUNTY COUNCIL.

WANDSWORTH TECHNICAL COLLEGE, as soon as possible.

TWO ASSISTANTS, GRADE A, to teach (1) Engineering Science and Mathematics. (2) Applied Mechanics and Engineering Drawing. Both are required for Ordinary National Certificate and City and Guilds courses. Graduate or equivalent qualifications, industrial and teaching experience desirable. Burnham F.E. salary scale varies between £486 and £917. Individual minimum and maximum salary according to age, qualifications and experience. Application forms from SECRETARY, AT COLLEGE, WANDSWORTH HIGH STREET, S.W.18, returnable by 4th February. (72). K 25

D.S.I.R. require an
ASSISTANT EXPERIMENTAL OFFICER at the Food Investigation, Ditton Laboratory, near Maidstone, Kent, for experimental engineering and physical work in the field of refrigeration applied to the preservation of food. G.C.E. Advanced Level in Mathematics and one Science Subject, plus Physics at ordinary level. Over 22, candidates will generally be expected to have pass degree, H.N.C. or equivalent. Inclusive salary 45½ hour week (Men), £315 (age 18) to £690, (Women) £315 to £601. Equal Pay Scheme. Application forms from M.L.N.S., TECHNICAL AND SCIENTIFIC REGISTER (K), 26, KING STREET, LONDON, S.W.1, quoting C225/5/ B.G. Closing date, 4th February, 1956. K 23

NORTH WEST METROPOLITAN
REGIONAL HOSPITAL BOARD.

The Board are engaged on a number of new building and engineering projects, including a new hospital at Welwyn, and the following staff are required to fill a number of newly created posts on the establishment of the Regional Engineer.

ASSISTANT ENGINEERS—ELECTRICAL, MECHANICAL, HEATING AND VENTILATING. Applicants must be at least (*a*) Graduate Members of the Institution of Electrical Engineers, and have passed the Institution examination (lately the Associate membership examination) or recognised exempting examinations; or (*b*) Graduate Members of the Institution of Mechanical Engineers, and have passed Section A and B of the Associate membership examination, or recognised exempting examinations; or (*c*) Graduate Members of the Institution of Heating and Ventilating Engineers, and have passed the Associate membership examination, or recognised exempting examinations. Salary scale £640 by £25 (4) by £30 (4) by £25 (2) to £930, plus £20 to £40 London Weighting.

ENGINEERING ASSISTANTS. Applicants must have O.N.C. or other approved qualification in appropriate engineering subjects. Salary scale—£480 (age 21 or over) by £20 (7) by £25 (2) to £670, plus £20 to £30 London Weighting.

Posts are subject to Whitley Council conditions and are superannuable. Starting salaries may be above minimum having regard to extent of experience since obtaining appropriate qualification.

Apply, stating which post, and giving age, qualifications (with dates) and experience together with the names and addresses of two referees, to SECRETARY, NORTH WEST METROPOLITAN REGIONAL HOSPITAL BOARD, 11A, PORTLAND PLACE, LONDON, W.1, by 13th FEBRUARY, 1956. K 43

COUNTY BOROUGH OF DONCASTER
EDUCATION COMMITTEE.

DONCASTER TECHNICAL COLLEGE.
PRINCIPAL: W. LOMAX, M.Eng., B.Sc., M.I.Min.E.

Applications are invited for the post of **ASSISTANT, GRADE B, IN THE MECHANICAL ENGINEERING DEPARTMENT** at the above College.

The successful candidate will be expected to teach Production Engineering to Higher National Certificate and Final City and Guilds Standard in the subjects: Metrology and Machine Tools and Workshop Technology and Practical Workshop. Candidates should possess Associate Membership of the Institution of Production Engineers or similar qualification, and have had considerable practical experience. Salary in accordance with Burnham (Technical) Scale, Grade B.

Application forms may be obtained from the undersigned and should be completed and returned as soon as possible.

V. H. HOSKIN,
Chief Education Officer.

Education Offices,
Whitaker Street,
Doncaster. K 7

UNIVERSITY OF LONDON KING'S COLLEGE will require on 1st April, 1956, or as soon thereafter as possible,
A LECTURER IN CIVIL ENGINEERING and a **LECTURER IN MECHANICAL ENGINEERING.** Applicants should be honours graduates with some practical experience and an interest in research. Salary on the scale £700 by £50 to £1400 with starting point according to qualifications and experience, together with Family Allowances and F.S.S.U. benefits.—Particulars and Application forms from the REGISTRAR, KING'S COLLEGE, STRAND, W.C.2, whom completed applications must reach by 29th February. J 991

DRAUGHTSMEN—MECHANICAL ENGINEERING—required by MINISTRY OF SUPPLY, R.O.F., BURGHFIELD, NR. READING, BERKS. Quals.—Engineering apprenticeship or 3 years workshop experience and O.N.C. or equiv., with appropriate draughtsman experience. Starting pay, according to age, £443 10s. (age 21) to £605 (age 28) to £695. Five-day week of 44 hours incl. meal breaks. Paid overtime and sick leave. 20 days annual holiday in addition to public hols. Opportunities for promotion. Houses will be available in a few weeks for married staff recruited from outside daily travelling distance from the factory.—Apply, stating age, training, quals. and experience, to any EMPLOYMENT EXCHANGE, quoting Order No. Reading 51. K 21

MINISTRY OF SUPPLY requires
ENGINEER at Harefield, Middlesex, to lead section developing and applying electronic methods to the non-destructive testing of metallic and non-metallic materials and components. QUALIFICATIONS. British of British parents. Recognised engineering apprenticeship and either A.M.I.E.E. or Mech.E. or exempting qualifications. Must have several years' experience in applied electronics. Hons. physics graduate or Associate Institute of Physics will be considered. SALARY. Within £1055 to £1335. Not established but opportunities to compete for establishment may arise. Application forms from M.L.N.S., TECHNICAL AND SCIENTIFIC REGISTER (K), 26, KING STREET, LONDON, S.W.1, quoting D614/5A/B.G. K 19

MINISTRY OF SUPPLY require
MECHANICAL ENGINEERS at FIGHTING VEHICLES RESEARCH AND DEVELOPMENT ESTABLISHMENT, NEAR CHERTSEY, SURREY, to investigate problems in automotive engineering, mainly associated with extreme conditions under which military vehicles are required to operate. Appointment according to age, experience, etc., as

SCIENTIFIC OFFICER (min. age 21), or **SENIOR SCIENTIFIC OFFICER** (min. age 26). Quals.:—1st or 2nd class honours degree or equivalent qualification in Mechanical Engineering. Knowledge of automobile engineering and experience in vibrational problems desirable. Salaries within range, S.O. £488 10s. to £885. S.S.O. £1030 to £1185 (Superannuable). Application forms from M.L.N.S., TECHNICAL AND SCIENTIFIC REGISTER (K), 26, KING STREET, LONDON, S.W.1, quoting C/988/5A/B.G. K 18

ENGINEER (SENIOR GRADE) required by the ATOMIC WEAPONS RESEARCH ESTABLISHMENT, FOULNESS, ESSEX, to take charge of a small but broadly based engineering group covering mechanical, electrical, electronic and civil engineering. Applicants should have served a recognised engineering apprenticeship and either be corporate members of one of the senior Institutions or possess exempting qualifications. They should also have wide experience in all the above branches on an industrial or commercial footing. Some experience of research or prototype engineering would be a considerable advantage.

SALARY £1490-£1685 p.a. Contributory Superannuation scheme. Housing will be available for married officers who live outside daily travelling distance of the establishment at a later date, alternatively assistance towards legal expenses incurred in house purchase may be payable.

Requests for application forms by POSTCARD to the SENIOR RECRUITMENT OFFICER AT A.W.R.E., ALDERMASTON, BERKS. Quote reference 868/26. J 992

ENGINEERS AND CHEMISTS.

Vacancies exist with the Industrial Group of the UNITED KINGDOM ATOMIC ENERGY AUTHORITY for the above posts in the Research and Development Branch, at Windscale, Sellafield, Cumberland.

WORKSHOPS ENGINEER (reference 1,239)

DUTIES: To be responsible for the day-to-day operation of a workshop serving a large Research Department. The work includes the construction of a wide range of special experimental equipment and the erection of large scale experimental rigs.

QUALIFICATIONS AND EXPERIENCE: Candidates should be Corporate Members of the Institution of Mechanical Engineers or hold equivalent qualifications and should have previous experience in the control of engineering workshops.

SALARY: £728 rising by annual increments of approximately £30 to £1130 p.a.

WELDING ENGINEERS (reference 1,240).

DUTIES: To undertake work on a wide variety of welding problems, mainly on stainless steel, and low alloy steels, including the following:—

(*a*) The application of current welding techniques to difficult problems encountered in the design of plant for atomic energy installations.

(*b*) The design and development of equipment for carrying out welding by automatic processes or by remote control.

(*c*) Non-destructive testing methods.

QUALIFICATIONS AND EXPERIENCE: Candidates should be Corporate Members of the Institution of Mechanical or Electrical Engineers or hold equivalent qualifications and should have previous experience in the welding field.

SALARY: Grade II, £1130 rising by annual increments of approximately £40 to £1435 p.a. Grade III, £728 rising by annual increments of approximately £30 to £1130 p.a.

DEVELOPMENT MANAGER
(reference 1,241).

DUTIES: To take charge of a section responsible for works development. The work involves collaboration with works production personnel and the initiation of experimental work to improve the efficiency of operation of works processes.

QUALIFICATIONS AND EXPERIENCE: Candidates should hold an honours degree in Chemistry, Chemical Engineering or Physics or equivalent and should have experience in the operation of works chemical processes and of applied research and development.

SALARY: £1490 rising by annual increments of approximately £45 to £1685 p.a.

Successful candidates under 55 will be required to join the Authority's Contributory Pension Scheme, which includes widows' and dependants' benefits.

There is a housing scheme for married officers.

Suitably qualified persons are invited to send a post-card quoting the appropriate reference number for form of application to RECRUITMENT OFFICER, U.K.A.E.A., INDUSTRIAL GROUP HEADQUARTERS, RISLEY, NR. WARRINGTON.

Closing date, 3rd February, 1956. J 990

Classified Advertisements continued on Page 4

Mc Graw-Hill

Documents of the
US ATOMIC ENERGY COMMISSION

THIS COLLECTION OF SELECTED reference materials was assembled by the United States Atomic Energy Commission to help scientists in other countries interested in the development and use of nuclear energy. Sets of these documents were sent to the delegates of each nation attending the International Conference on the peaceful uses of Atomic Energy held at Geneva in August this year.

The material is designed to provide a practical basic source of technical information on nuclear energy and its applications. It is now being published by McGraw-Hill in six volumes:

Research Reactors
10 × 8 inches **460 pages 49s**
Detailed descriptions of six types of reactor: three moderated by light water, one by heavy water, one by hydrocarbon and one by graphite.

Neutron Cross Sections
16 × 10 inches **363 pages 90s**
A table of thermal-neutron cross-section measurements, with a series of graphs in which measurements for individual isotopes are plotted as a function of neutron energy.

Reactor Handbook—Physics
10 × 8 inches **804 pages 90s**
Theoretical and experimental techniques in reactor physics and radiation shielding.

Reactor Handbook—Engineering
10 × 8 inches **1,008 pages 112s 6d**
Basic reactor systems applicable to power development, with a summary of experimental designs.

Reactor Handbook—Materials
10 × 8 inches **614 pages 79s**
Detailed information on fuels, moderators, shielding and structural material for reactors.

Chemical Processing & Equipment
10 × 8 inches **316 pages 45s**
Data on the safe handling of highly radioactive materials.

Available from your Bookseller.

McGraw-Hill Publishing Co Ltd
McGraw-Hill House London EC4

MINISTRY OF SUPPLY requires
ENGINEER in London H.Q. to plan and progress production of radio valves, cathode ray tubes and photo-electric cells. QUALIFICATIONS. British of British parents. Recognised engineering apprenticeship, or equivalent in electronics, and A.M.I.E.E. or Mech.E. or exempting qualifications. Must have wide production experience in radio valve industry; detailed knowledge Service requirements an advantage. SALARY. Within £1095 to £1415. Not established but opportunities to compete for establishment may arise. Application forms from M.L.N.S., TECHNICAL AND SCIENTIFIC REGISTER (K), 26, KING STREET, LONDON, S.W.1, quoting D390/5A/B.G. Closing date 10th February, 1956. K 20

METALLURGIST required by MINISTRY OF SUPPLY, Fighting Vehicles Research and Development Establishment, near Chertsey, Surrey, on research and practical investigation into problems connected with manufacture and heat-treatment of components for armoured fighting vehicles. Quals.:—1st or 2nd class honours degree or equivalent qualification in metallurgy. Research or works experience and a knowledge of heat-treatment of carbon and alloy steels desirable. Salary within Scientific Officer range:—£488 10s. to £885 (Superannuable). Application forms from M.L.N.S., TECHNICAL AND SCIENTIFIC REGISTER (K), 26, KING STREET, LONDON, S.W.1, quoting F.975/5A/B.G. Closing date 15th February, 1956. K 22

LONDON COUNTY COUNCIL.

ARCHITECT'S DEPARTMENT.

Vacancies for
ENGINEERING ASSISTANTS (up to £783) and Engineer Grade III (up to £945) in the Structural Engineering Division. Work includes steelwork and reinforced-concrete design and detailing for Council's buildings. Particulars and application forms from Architect (AR/EK/SE/1), THE COUNTY HALL, S.E.1. (1273). G 573

UNIVERSITY OF NOTTINGHAM.

SENIOR RESEARCH FELLOWSHIP IN PRODUCTION ENGINEERING.

Applications are invited for appointment to a Senior Research Fellowship in Production Engineering, within the scale £1350 to £1750, tenable for three years in the first instance. Further information and form of application may be obtained from the undersigned.

H. PICKBOURNE,
REGISTRAR K 76

BRITISH RAILWAYS RESEARCH DEPARTMENT.

Vacancy for
SCIENTIFIC OFFICER, GRADE 2 IN ENGINEERING DIVISION, Derby.
Experimental work in electronics.
Science degree essential.
Salary range £575 to £850.
Superannuation and certain free travel facilities.
Medical examination.
Write stating age, qualifications and experience to:—

DIRECTOR OF RESEARCH,
BRITISH RAILWAYS DIVISION,
BRITISH TRANSPORT COMMISSION,
222, MARYLEBONE ROAD,
LONDON, N.W.1. K 83

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD.

TWO ASSISTANT ENGINEERS required in the Civil and Hydraulic Engineering Department at the Board's Head Office in Edinburgh. Candidates should be Corporate Members of the Institution of Civil Engineers and have a good knowledge of civil engineering practice and design with particular reference to hydro-electric development.

One vacancy is on salary scale £875 to £1060 per annum and the other on salary scale £675 to £840 per annum (N.J.B. Schedule "C" Class AX/CX, Grades 3 and 5 respectively) with placing on these scales according to technical qualifications and experience.

A vacancy also exists for a General Assistant Engineer having qualifications exempting from Parts I and II of the Associate Membership examination of the I.C.E. Salary range £475 to £590 (N.J.B. Schedule "C" Class AX/CX, Grade 7).

Superannuation Scheme applicable.

Application Forms may be obtained from THE SECRETARY, 16, ROTHESAY TERRACE, EDINBURGH, 3, and should be returned within 14 days from the publication of this notice. K 66

MIDDLESBROUGH EDUCATION COMMITTEE.

CONSTANTINE TECHNICAL COLLEGE.

PRINCIPAL: G. S. ATKINSON, B.Sc., Ph.D.

Applications are invited for the undermentioned appointments.

1. **SENIOR LECTURER IN METALLURGY,** to be responsible for courses up to A.I.M. Standard and for the development of research in the subject. Salary £1065 by £25 to £1215. Duties to commence September, 1956.
2. **ASSISTANT GRADE B IN MECHANICAL ENGINEERING,** to teach up to Higher National Diploma standard. Applicants should have a degree or appropriate qualification and experience. Salary £525 by £25 to £820 with additions for training and experience. Duties to commence as soon as possible.
3. **ASSISTANTS GRADE A IN:—**
   (*a*) Chemistry.
   (*b*) Structural Engineering.
   Salary £450 by £18 to £725 with additions for training and experience. Duties to commence as soon as possible.

Forms and further particulars are available from DIRECTOR OF EDUCATION, WOODLANDS ROAD, MIDDLESBROUGH, to whom applications should be returned within 14 days of the appearance of this advertisement. K 77

KENT COUNTY COUNCIL
require a
FUEL ENGINEER having a wide experience of the efficient combustion of solid and liquid fuels, the application of automatic controls and the preparation of efficiency reports on large heating systems. Salary within scale £710 to £885. Application forms from COUNTY ARCHITECT, SPRINGFIELD, MAIDSTONE. Closing date 2nd February, 1956. K 51

CITY OF LEICESTER.

EDUCATION COMMITTEE.

COLLEGE OF TECHNOLOGY AND COMMERCE.

PRINCIPAL: R. E. WOOD, M.Sc., F.Inst.P.

Applications are invited for the post of
ASSISTANT (GRADE B), in the School of Engineering, for Mechanical Engineering subjects for Ordinary National Certificate and City and Guilds of London Institute courses.

Salary will be in accordance with the Burnham Technical Scale £525 by £25 to £820 per annum, with additions for degree and training and increments for approved teaching and/or industrial experience and War Service.

Forms of application and further particulars can be obtained from the REGISTRAR, COLLEGE OF TECHNOLOGY AND COMMERCE, THE NEWARKE, LEICESTER, to whom completed forms should be returned as soon as possible.

ELFED THOMAS,
DIRECTOR OF EDUCATION. K 57

APPOINTMENTS OPEN.

THE ENGAGEMENT OF PERSONS answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order 1952.

It is advisable when sending testimonials to forward copies and NOT originals.

NORTH BRITISH LOCOMOTIVE CO., LTD.,
DIESEL ENGINE DIVISION, requires
A DRAUGHTSMAN capable of preparing layouts for engines and supervision of detailing. Pension scheme, five-day week.—Apply in writing to (IGD) PERSONNEL MANAGER, SPRINGBURN, GLASGOW, N.1. K 16

B.I.P. CHEMICALS LIMITED, OLDBURY.
PLANT ENGINEER is required for maintenance and development work in a factory manufacturing synthetic resins and cements. Preference will be given to applicants having Chemical Engineering qualifications and experience of Chemical plant work.—Full details of education and experience should be sent to the CHIEF ENGINEER, B.I.P. CHEMICALS LIMITED, TAT BANK HOUSE, OLDBURY, BIRMINGHAM. J 947

RESEARCH ENGINEER OR PHYSICIST

with advanced knowledge of thermodynamics required by a Glasgow Engineering Company. Applicants, aged 25-30, should have a University Honours Degree. Experience in heat transfer problems would be an advantage. Salary depending on qualifications and experience.—Apply to BOX G 583, Offices of ENGINEERING.

JUNIOR DRAUGHTSMEN, having completed National Service, required for work on large chemical plant installations. A.E.S.D. minimum rates or above. Five-day week and superannuation scheme.—Apply by letter giving details of technical education to the CHIEF DRAUGHTSMAN, LAPORTE CHEMICALS LIMITED, CLIFTON HOUSE, EUSTON ROAD, LONDON, N.W.1. G 575

BRITISH PETROLEUM COMPANY LIMITED offers
STUDENT APPRENTICESHIPS IN MECHANICAL AND CHEMICAL ENGINEERING for men who have completed their period of National Service and who possess G.C.E. in five subjects of which Mathematics and/or Physics must have been passed at "A" level and English at "O" level. Age 19-22. The apprentices will attend a Technical College for a full-time Sandwich Course of Studies during their first six months and will then go to a Refinery for practical training. The Course is of 4 years duration.—Applications giving full details of education and experience should be addressed to MANAGER, RECRUITMENT BRANCH, quoting reference H.3570, to BOX 8347, c/o 191, GRESHAM HOUSE, E.C.2. G 608

MECHANICAL AND ELECTRICAL SERVICES ENGINEER required by Consulting Engineers in Birmingham. Permanent post with pension scheme.—Reply in confidence giving qualifications, previous experience, age, etc., to BOX No. 309, GLOVERS ADVERTISING LTD., 351, OXFORD STREET, LONDON, W.1. G 596

SENIOR MECHANICAL ENGINEERING DRAUGHTSMEN required for interesting work on large chemical plant installations. Experience in this type of work is desirable but not essential, applicants with general mechanical engineering experience will be favourably considered. The posts offer excellent opportunities with generous salaries commensurate with experience and ability. Offices situated in the N.W.1 London area. Five-day week and superannuation scheme.—Applications, which will be treated in confidence, should give previous experience and qualifications and be addressed to the CHIEF DRAUGHTSMAN, LAPORTE CHEMICALS LIMITED, CLIFTON HOUSE, EUSTON ROAD, LONDON, N.W.1. G 576

Are you looking for interesting and varied work connected with Design, Development and Testing of a wide variety of new pieces of equipment for mechanical handling in Collieries and for Railway Signalling? We have vacancies for young men with ideas to work on mechanical, pneumatic and/or Electro-mechanical projects.

You are not expected to have had experience of this particular type of work and training will be arranged where necessary for successful applicants. Some of the posts may well be filled by those with a few years' experience as a design draughtsman.

POSTS ARE AVAILABLE FOR GRADUATES OR FOR THOSE STILL STUDYING FOR THEIR NATIONAL CERTIFICATES IN MECHANICAL OR ELECTRICAL ENGINEERING and starting salaries will be in accordance with age, experience and qualifications. There is excellent scope for advancement for those with ability and initiative. Five-day week and pension scheme. For further information apply to PERSONNEL SUPERINTENDENT, WESTINGHOUSE BRAKE & SIGNAL CO. LTD., CHIPPENHAM, WILTS., quoting reference No. EQUIP/N/L/. J 878

BRITISH PETROLEUM COMPANY LIMITED has a vacancy for a
STATISTICIAN in the Physics Section at its Research Station at Sunbury-on-Thames. Applications are invited from men who have completed a degree course in Statistics or who have had equivalent experience. Work will be on statistical problems in the oil industry including statistical design of experimental programmes. Applicants should be capable of co-operating fully with Research Staff and of ensuring that statistical techniques are used to the best advantage. Knowledge of the oil industry is not an essential. Excellent working conditions. Non-contributory Pension Scheme and Luncheon Club facilities. Write giving full details, quoting H.3308, to BOX 8207 c/o 191, GRESHAM HOUSE, E.C.2. G 597

UNILEVER LTD. invite applications from qualified **MECHANICAL ENGINEERS** for an appointment in the Engineering Department of their London Office to advise associated companies on boiler installations, efficient use of fuels, and steam distribution. Candidates should have qualifications equivalent to Corporate Membership of the Institution of Mechanical Engineers and a good practical training; they should in addition have had industrial experience of the operation of boilers and the planning of steam generating and distribution systems.—Written applications giving full particulars of qualifications, training and experience to be addressed to: PERSONNEL DIVISION (WAD 102), UNILEVER LTD., UNILEVER HOUSE, BLACKFRIARS, E.C.4. J 895

CHAPMAN & HALL

Ready this month

HANDBOOK OF

BARREL FINISHING

by

RALPH F. ENYEDY

(Electronic Tube Division, Westinghouse Electric Corpn.)

10¼" × 7" *255 pages* *Illustrated* *60s. net.*

In this book will be found the complete details of this precise, economical method of finishing metal and plastic parts. Every phase from cleaning and deslugging to colouring, polishing and burnishing is covered in sequence. More than 150 complete specification sheets provide all the information necessary for finishing a large variety of parts, and latest developments in equipment, finishing compounds and methods are described in detail.

ELECTRONIC TRANSFORMERS AND CIRCUITS

by

REUBEN LEE

(Advisory Engineer, Westinghouse Electric Corpn.)

Second Edition

9¼" × 6" *360 pages* *Illustrated* *60s. net*

This clear and practical book offers extremely useful data on the design of transformers for electronic apparatus and on the effects of transformer characteristics on electronic circuits. The second edition has been expanded to cover new developments and to provide fuller discussion of certain topics.

Just Published

STEELS FOR THE USER

by

R. T. ROLFE, O.B.E., F.R.I.C., F.I.M.

Third Edition—Revised and Enlarged

8½" × 5½" *416 pages* *Illustrated* *45s. net*

This book, which effectively bridges the gap between science and practice for carbon steels in industry, has been generally recognised as a work of the greatest value to engineers and all users of steel. Extensive revisions and the addition of new material and illustrations to the present edition have brought the work completely up-to-date.

37 ESSEX STREET, LONDON, W.C.2

DESIGNERS and DRAUGHTSMEN required by
BRITISH OXYGEN ENGINEERING
LIMITED (PLANT DEPARTMENT)
AT EDMONTON AND HARLOW

Excellent opportunities are offered to Designers and Draughtsmen with good qualifications and experience in one or other of the following:

★ Pressure Vessels ★ Pumps and Compressors
★ Pipework ★ Chemical Plant
★ General Mechanical Engineering

The Company offers EXCELLENT SALARIES and prospects of ADVANCEMENT together with ideal welfare facilities, including a PENSION FUND.

APPOINTMENTS FOR DESIGNERS AND DRAUGHTSMEN WILL BE MADE AT THE COMPANY'S OFFICES AT EDMONTON OR HARLOW.

AT HARLOW RENTED ACCOMMODATION IS AVAILABLE AND REMOVAL EXPENSES ARE PAID. AT EDMONTON, HOUSE PURCHASE FACILITIES ARE AVAILABLE AND REMOVAL AND LEGAL EXPENSES ARE PAID.

Applications, giving full details of qualifications, experience, present salary and salary required, to the Staff Officer, British Oxygen Engineering Limited, Angel Road, Edmonton, London, N.18. J 748

TWO JUNIOR ENGINEERING DRAUGHTSMEN required by THE AVON INDIA RUBBER CO., MELKSHAM. Age approximately 21-24, and must have completed National Service. Preferably of O.N.C. standard and studying for H.N.C. This is a good opportunity for young men to carve themselves out an interesting and progressive career with an expanding Company in a Department handling a wide variety of Engineering work.—Reply to the CHIEF ENGINEER. J 821

DRAUGHTSMAN FOR MAINTENANCE AND DEVELOPMENT OF SEAMLESS STEEL TUBE PLANT. Heavy engineering and Hydraulic experience desirable. Five-day week. Permanent pensionable position to suitable applicant. Special rate will be paid to man of high ability and qualifications.—Write, stating full particulars, to the CHIEF ENGINEER, STEWARTS & LLOYDS, LIMITED, BROMFORD TUBE WORKS, WHEELWRIGHT ROAD, ERDINGTON, BIRMINGHAM, 24. J 830

UNILEVER LTD. invite applications from **MECHANICAL ENGINEERS** for the following types of appointment with manufacturing companies situated in Yorkshire, Lancashire, Cheshire and the London area. Academic qualifications to at least the equivalent of Graduate Membership of the Institution of Mechanical Engineers and a workshop training are essential in all cases.

(*a*) Junior Engineers with good basic training in the age group 22/27.
(*b*) Engineers for development work and special investigations.
(*c*) Engineers with industrial experience of plant maintenance.
(*d*) Engineers with industrial experience and some knowledge of steam generation and electrical installations.

Written applications, giving full particulars of qualifications, training and experience, to be addressed to: PERSONNEL DIVISION (WAD 101), UNILEVER LTD., UNILEVER HOUSE, BLACKFRIARS, E.C.4. J 894

COAL PREPARATION SALES MANAGER

Applications are invited in the Chesterfield Office of The Birtley Company Limited for the post of Coal Preparation Sales Manager. Intending applicants should already be in close contact with Divisional and Area levels of the N.C.B., and possess up-to-date experience in Coal Preparation. Salary according to suitability and qualifications. Applications should be addressed to:

THE SECRETARY,
THE BIRTLEY COMPANY LIMITED,
BIRTLEY, Co. DURHAM

stating age, qualifications and salary required. K 64

THE AVON INDIA RUBBER CO., LTD., MELKSHAM, WILTS., require an **ELECTRICAL DRAUGHTSMAN.** He should be experienced with power and lighting distribution and motor control-gear work, and should possess at least O.N.C. qualification. Salary and working conditions will be made attractive to the right man.—Apply CHIEF ENGINEER, giving age and full particulars. J 913

An expanding and well-known London Light Engineering Company wishes to appoint a **SENIOR EXECUTIVE** to take full charge of Engineering and the Administration of two Factories, one of which is in the provinces. This is a new appointment and should lead to a seat on the Board. Candidates should be between 40 and 45, have an Honours Degree in Mechanical Engineering, and have already held a position as Works Manager. Sound knowledge of the administration of a Design Office, Budgetary Control, Production Planning, Work Study and Estimating are essential and in addition familiarity with techniques of Machining, Welding and Assembly. This position will carry a salary of not less than £2000 per annum and will be pensionable. Candidates should give details of scholastic career at school and subsequently, positions held, salaries earned in each, and brief particulars of experience gained.—Reply in full confidence to BOX J 908, Offices of ENGINEERING.

ENGINEER FOR WEST AFRICA for the operation and maintenance of Vegetable oil producing factory. Candidates must be of good education; preferably at least G.I.Mech.E. or equivalent; age 26 to 33; experienced in plant maintenance. A good practical experience of Steam Boilers and engines is essential preferably including knowledge of centrifuges, diesel engines and small electrical installations. The post is one of responsibility for efficient processing, control of staff, training of Africans and maintenance upkeep of transport vehicles.

Commencing salary not less than £1000 per annum. In addition there are family allowances, free furnished accommodation and medical attention provided in Africa, membership of Pension fund. Tours of about 21 months with leave on full pay. Free first class passages including family.

Apply giving details of education, qualifications and experience to BOX J 736, Offices of ENGINEERING.

ENGINEERS UNDER 30 YEARS OF AGE with G.I.Mech.E. or equivalent qualification required in the London Office of a large Manufacturing Company. Successful applicants would have to undertake some travel in the United Kingdom and might even have to make occasional trips overseas to visit Manufacturers and Associated Companies. Applicants should have had experience of conducting technical correspondence. The posts are permanent and pensionable and the Company has a Staff Restaurant.—Apply in writing, giving full details of education and career, to BOX J.925, WILLING'S 362, GRAYS INN ROAD, LONDON, W.C.1. J 929

Applications are invited from **SENIOR DRAUGHTSMEN** with experience of Materials Handling for the position of Head of the Projects Drawing Office of a progressive and well-established company in the Midlands. A summary of qualifications and experience of bulk handling of coal, coke, ores, etc., with salary required will be treated confidentially.—BOX J 897, Offices of ENGINEERING.

DESIGN DRAUGHTSMEN.

THE BRITISH DRUG HOUSES LTD. invite applications from suitably qualified men for interesting work in their Engineer's Drawing Office, on special machines and plant layouts for the Light Chemical Industry. Higher National Certificate in Mechanical Engineering and previous experience in this industry desirable but not essential. Men of mature age with suitable training and experience would be considered. Five-day week. Pension and Profit Sharing Schemes.—Write, stating age, experience and salary required, to STAFF MANAGER (REF. B8912), GRAHAM STREET, CITY ROAD, N.1. J 792

ARMSTRONG SIDDELEY MOTORS have vacancies for both

SENIOR AND JUNIOR ENGINEERS

for investigation of vibration problems on gas turbine development engines. Degree or H.N.C. in Mechanical Engineering or Electrical Engineering essential. Electrical Engineers should have some mechanical engineering experience. Applicants must be capable of using necessary recording equipment. Salaries commensurate with qualifications and experience, together with good pension scheme.—Applications to REFERENCE CG/VP, TECHNICAL PERSONNEL MANAGER, ARMSTRONG SIDDELEY MOTORS, COVENTRY. G 621

INSULATION RESEARCH ENGINEER.

BRUSH ELECTRICAL ENGINEERING CO., LTD., require a **QUALIFIED ELECTRICAL RESEARCH ENGINEER** in the Insulation Department of their Research Division. His duties will include the investigation and development of new insulating materials, techniques and processes applicable to a wide range of products including bushings, rotating machines, switchgear and transformers, and research into discharge and high voltage breakdown phenomena. Applicants for this responsible position, which has excellent prospects, should have a degree, some experience in this field and the initiative to organise and supervise research projects; conditions include non-contributory superannuation scheme and staff bonus. Apply in writing giving details of qualifications, age, experience, etc., to:

THE CHIEF PERSONNEL OFFICER,
BRUSH ELECTRICAL ENGINEERING CO., LTD.,
LOUGHBOROUGH,
LEICS. J 861

STRUCTURAL DESIGNER required for busy London Office handling a wide variety of building schemes. Considerable scope for advancement is available to a reliable man with initiative who can work with minimum supervision and deal with site matters.—BOX J 753, Offices of ENGINEERING.

EXPERIENCED DRAUGHTSMEN for Detailing Structural Steelwork. Good salaries. Five-day week. Pension Scheme. Canteen facilities. State experience and age when applying to THE DIRECTORS, JOHN BOOTH & SONS (BOLTON), LTD., HULTON STEELWORKS, BOLTON. J 754

DRAUGHTSMEN.

BEXFORD, LTD., BRANTHAM, NR. MANNINGTREE, ESSEX, manufacturers of photographic film base, have vacancies for

FIRST-CLASS SENIOR AND JUNIOR MECHANICAL DESIGN AND DETAILING DRAUGHTSMEN at their up-to-date factory on the borders of Essex and Suffolk. Men in the older age groups will be considered. The work which is interesting covers a wide field in the design and development of machinery for the manufacture of photographic film base. The positions are permanent, and carry salaries of £750 per annum to Seniors, and wages above new A.E.S.D. rates to detail Draughtsmen. The Company has a contributory pension scheme, and offers facilities and conditions associated with first-class employers.—Please write, giving age, details of training and experience, to the PERSONNEL MANAGER, BEXFORD LTD., BRANTHAM. J 909

BRITISH CELLOPHANE LIMITED, BRIDGWATER, SOMERSET, seeks

SENIOR AND JUNIOR DRAUGHTSMEN, for both **PERMANENT AND TEMPORARY** appointments, for work on machine design and chemical plant layout. Applicants should possess at least O.N.C. and have had three years' shop experience. Five-day week, Pensions Fund scheme for permanent appointments. Ref. No. E44.Eg.

THE TEMPORARY appointments are for a period of approximately two years' duration, subject to three months' notice and include generous subsistence allowances, and periodic home return rail fares.

ESTIMATOR (PERMANENT). Applicants should have served an engineering apprenticeship and have technical education up to O.N.C. standard. The work involved will be on the preparation of material and labour specifications in connection with engineering work, electrical estimating experience an advantage. Ref. No. E46.Eg.

ASSISTANT ENGINEER, AGE 23/30 (PERMANENT). Applicants should have an honours degree in mechanical engineering and have had some practical works experience. The duties will be on development, improvement and maintenance of chemical and other plant. Ref. No. E45.Eg.

ASSISTANT ENGINEER, AGE 25/30 (PERMANENT). Applicants should have a university degree and have works experience, or be an A.M.I.Mech.E. The duties will be on development, improvement and maintenance of plastic films extrusion plant and ancillary equipment. Ref. No. R43.Eg.

Write to the PERSONNEL OFFICER, stating full particulars and salary required, and quote Ref. Nos. as indicated. J 912

Required by THE AVON INDIA RUBBER CO., MELKSHAM, WILTS., one **SENIOR ENGINEERING DRAUGHTSMAN.** H.N.C. standard desirable and should be experienced in general engineering work, factory layouts and, if possible, special-purpose equipment design. Attractive salary paid for the right man.—Reply to the CHIEF ENGINEER. J 820

RUSTON-BUCYRUS LTD.
Excavator Specialists

invite applications from qualified engineers for appointment as

PRODUCTION MANAGER.

Basic requirements are University Degree in Engineering or Corporate Membership of one of the Professional Institutions plus practical knowledge of modern production systems, the latter is particularly important. This is an interesting and high level appointment in a modern and fully equipped works in the medium/heavy engineering industry.

Interested applicants should write in first instance giving age and all relevant particulars including approximate salary required, to:

PERSONNEL MANAGER,
RUSTON - BUCYRUS LTD.,
EXCAVATOR WORKS,
LINCOLN.

J 763

WORKS ENGINEER.

Required for medium sized light engineering factory, engaged in a considerable re-organisation programme for its two factories.

Applicants would be required to control all functions of factory maintenance and to co-ordinate existing departments.

Experience is required of repair and alteration of factory buildings, services, heating and ventilating, and power supply. A detail knowledge of preventative maintenance schemes for services and machine tools essential.

Preference will be given to a Chartered Engineer, below the age of 50. This is a senior staff position, with generous salary. A non-contributory superannuation scheme is in operation.

Applicants should submit full details of career and salaries to CLAYTON DEWANDRE CO., LTD., TITANIC WORKS, LINCOLN, for the attention of the General Manager. J 914

The Generation of Electricity by Wind Power
E. W. GOLDING, M.SC.TECH., M.I.E.E., M.AMER.I.E.E., F.R.G.S.
Demy 8vo. 336 pages, 101 diagrams, 28 plates, 50s. net.
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Crown 4to, 192 pages, 63 figures, 24 plates, 50s. net.
"A very useful contribution . . . Simple and straightforward and liberally illustrated." PETROLEUM TIMES.

Model Analysis of Structures
T. M. CHARLTON, B.SC. (ENG.) (LOND.), A.M.I.MECH.E.
Med. 8vo, 160 pages, 50 figures, 9 tables, 21s. net.
"A book written by one who really knows what he is talking about, on a subject whose importance is gradually being realised; it makes an important contribution." STRUCTURAL ENGINEER.

22 HENRIETTA ST. **E. & F. N. SPON** LONDON, W.C.2

Classified Advertisements continued on Page 6

ONTARIO (CANADA) A large and progressive firm of Consulting Engineers in Niagara Falls has vacancies for **DRAUGHTSMEN** with minimum of three years experience on REINFORCED CONCRETE preferably with experience on HYDRAULIC STRUCTURES.

Salary $250 to $375 a month dependent on experience and qualifications. Applicants should write or call for application forms DEPT. H.G.A. ONTARIO IMMIGRATION DEPARTMENT, 12, NEW BURLINGTON STREET, LONDON, W.1. K 10

DRAUGHTSMEN, SENIOR AND JUNIOR, required by a progressive Engineering firm making special-purpose labour saving plant in great demand. Top rates and excellent opportunity for competent men.—BOX J 766, Offices of ENGINEERING.

DESIGNER. PERMALI, LTD., require an experienced engineer. Problems include applications of laminated materials in electrical, mechanical, chemical, field. Heavy electrical plant apprenticeship and H.N.C. or degree essential. Age 30-45. Details career and present position in confidence to CHIEF ENGINEER, PERMALI, LTD., BRISTOL ROAD, GLOUCESTER. J 955

POSTS OF HIGH RESPONSIBILITY. One of the largest Rayon Factories in South America seeks a

GRADUATE CHEMIST with exceptional practical knowledge and proved managing experience also a Graduate Mechanical Engineer for post of Chief Engineer at the same Factory. Applications with full details, a recent photograph, stating experience and references to BOX JA/79 c/o 95, BISHOPSGATE, E.C.2. Replies will be treated with the utmost confidence. J 994

SITE ENGINEER required for rapidly expanding Company concerned with all aspects of plate fabrication. Successful candidate should be approximately 35 years of age and capable of developing and controlling an erection organisation, and of undertaking the site erection of large tanks, silos, hoppers, bunkers, etc. This position offers excellent opportunities for further promotion.—BOX J 977, Offices of ENGINEERING.

BUYER REQUIRED. A progressive Company on the North East Coast requires a buyer with considerable experience of purchasing basic materials and fittings for pressure vessels and tanks of all descriptions. The Company is mainly concerned with plate fabrication. Pension Scheme and Social facilities available.—BOX J 976, Offices of ENGINEERING.

London Engineers manufacturing for Petroleum industry require

JUNIOR MECHANICAL DRAUGHTSMAN AGE 20/26. Ord. Nat. Cert. and works experience desirable. A.E.S.D. rates. Pensionable post.—BOX J 971, Offices of ENGINEERING.

BILLINGHAM ICI DIVISION

Vacancies for

MECHANICAL ENGINEERS

The Billingham Factory of Imperial Chemical Industries Limited has grown into one of the largest chemical factories in the world. Some 250 Engineering graduates are already engaged in the various engineering activities necessary to maintain the Division's planned programme of extension, and more are needed.

A satisfying and well paid career is offered to

MECHANICAL ENGINEERS who are willing to assume early responsibility in the fields of

ENGINEERING RESEARCH, DESIGN, PROCESS ENGINEERING AND WORK STUDY. Opportunities for rapid advancement are excellent for men of ability.

These appointments are permanent and pensionable and carry attractive salaries. There is also a profit-sharing scheme in operation. Assistance can be given towards house purchase and removal expenses in the case of married men.

Write, giving full details of age, qualifications and experience to the STAFF MANAGER, IMPERIAL CHEMICAL INDUSTRIES LIMITED, BILLINGHAM DIVISION, BILLINGHAM, CO. DURHAM, quoting reference R.5. K 2

Leading firm of Management Consultants requires for its Canadian Subsidiary

MECHANICAL ENGINEERS AND ELECTRICAL ENGINEERS with managerial experience of production on a considerable scale. Permanent appointments in Canada on high scale salary after preliminary period in this country. Age 30 to 38 years. University degree or equivalent qualification.—Apply with full details to BOX J 730, Offices of ENGINEERING.

A BRITISH COMPANY handling world-wide agencies for leading manufacturers of all types of machinery requires

MECHANICAL ENGINEER for London Office. Preferably qualified with some commercial experience and under 30 years.—Write BOX "DE/141," c/o 95, BISHOPSGATE, E.C.2. J 851

ROLLS-ROYCE LIMITED, require competent **MECHANICAL ENGINEERS** for work on a new research project of exceptional interest in the field of nuclear energy. Attractively situated near Derby, the positions offer wide scope and a good salary.—Write to OH/MSN (C3) ROLLS-ROYCE LIMITED, P.O. BOX 31, DERBY. K 14

CHARLES ROBERTS & CO. LTD., RAILWAY CARRIAGE & WAGON BUILDERS, HORBURY JUNCTION, WAKEFIELD, have a vacancy for a **QUALIFIED ENGINEER,** aged about 30, whose principal duties will be to investigate the development of new techniques. This will be a very interesting position with excellent prospects. Applicants should state age and previous experience (not necessarily with rolling stock) to MANAGING DIRECTOR. K 15

SENIOR PROJECT ENGINEERS

LOCKHEED HYDRAULIC BRAKE CO., LTD., LEAMINGTON SPA, have a number of vacancies for Senior Project Engineers.

Applicants should possess an engineering degree or be eligible for membership of a recognised engineering institution and have had about 5 years engineering experience preferably in the automobile field. In addition they must have drive, initiative, a flair for original design, and the ability to direct the requirements of development testing.

These are senior appointments and the commencing salary will be commensurate with experience and qualifications.

Applications, in strictest confidence, should give full details of qualifications, experience and positions held, with salary, to:—

PERSONNEL OFFICER,
LOCKHEED HYDRAULIC BRAKE CO., LTD.,
TACHBROOK ROAD, LEAMINGTON SPA. K 49

JOHN LAING AND SON LIMITED

invite applications for the following technical staff vacancies resulting from promotion and expansion at the Research and Development Centre, Boreham Wood, Herts.

CHIEF MECHANICAL DESIGN ENGINEER.

In charge of Mechanical and Electrical Design Department. Preferably Chartered Mechanical Engineer, and an additional electrical qualification desirable. Adequate general engineering experience with specific design work on medium heavy plant and equipment. Age 30-50. Considerable opportunity for original design in a very wide field, together with general consultative services to the Company and its subsidiaries. Applicants must be adaptable and ready to tackle a wide variety of problems.

SENIOR MECHANICAL DESIGN ENGINEERS.

Qualifications and experience similar to the above though less advanced. Age 28-50.

ASSISTANT DESIGN ENGINEERS AND DRAUGHTSMEN.

Experience of mechanical design and detailing is desirable, but applications will be welcomed from graduates and those seeking to qualify professionally. Age 21 upwards.

The above posts are on a permanent basis, and are progressive and pensionable. The work is varied and interesting and holds attractive prospects in an expanding field. Five-day week.

Canteen and Sports Club facilities.

Apply in writing stating age, qualifications, and salary expected, to:—PERSONNEL MANAGER (M.18), JOHN LAING & SON LIMITED, BUILDING AND CIVIL ENGINEERING CONTRACTORS, LONDON, N.W.7. J 765

YOUNG DRAUGHTSMAN required by well-known Boiler and Pressure Vessel Manufacturers to train as Sales Representative. Able to make occasional site drawings. Age 21-25 years. State salary required. — BOX J 967, Offices of ENGINEERING.

MECHANICAL ENGINEER for medium and light engineering design. Experience of sheet metal fabrication batch production and special equipment, an advantage. Write giving full details to the PERSONNEL OFFICER, PHILIPS BALHAM WORKS, LTD., 45, NIGHTINGALE LANE, BALHAM, S.W.12. J 968

SENIOR AND INTERMEDIATE DRAUGHTSMEN AND DESIGN ENGINEERS required for offices situated at Forest Hill, S.E. London, for interesting and varied work covering Plant Layout, Machine Design and Detail Work for equipment for the Chemical and Allied Industries.

Five-day week, generous pension scheme and good prospects.

Applications in writing treated with strict confidence, CHIEF ENGINEER, DORR-OLIVER CO. LTD., 15, WILTON ROAD, LONDON, S.W.1. J 965

DRAUGHTSMEN WITH MECHANICAL EXPERIENCE are required for a small design group in a large manufacturing concern, East London area. Qualifications should include H.N.C. and apprenticeship. The work would include redesigning and modernising special purpose machinery, mainly for export. Permanent positions, non-contributory pension scheme, canteen, sports facilities, etc. Please send details of career to date, experience and salary required, to BOX 985, Offices of ENGINEERING.

TECHNICAL WRITER.

A technical qualification, especially in engineering or chemistry, and an interest in writing will be useful in this appointment for a technical writer offered by a Company making adhesives and resins for many industries. The preparation of technical bulletins and other literature constitutes the main part of this work. Pension scheme and canteen facilities are available. Please write, giving age and fullest particulars to: AERO RESEARCH LTD., DUXFORD, CAMBRIDGE. J 987

BRITISH PETROLEUM COMPANY LTD., has vacancy in MIDDLE EAST for

MECHANICAL ENGINEER, AGED 24-32. Applicants must possess H.N.C. and have served five year workshop apprenticeship. Machine and Fitting shop experience essential some knowledge of welding and overhauling pumps and C.I. engines desirable. Attractive salary plus generous allowance in local currency, free passage out and home, free medical attention, kit allowance, good leave arrangements. Pension scheme. Apply giving full details of qualifications and experience quoting F.512 to BOX 1690 c/o 191, GRESHAM HOUSE, E.C.2. J 973

MAINTENANCE ENGINEER required to take charge of mechanical and electrical installations in T.U.C. Memorial Building, Great Russell Street, W.C.1. This new building has oil fired boiler plant, embedded panel heating, is partly air conditioned with refrigeration, has comprehensive electric lighting and power installation, and high speed passenger lifts. Applicants having experience of maintenance of such installations should write giving qualifications, experience and present salary to SIR VINCENT TEWSON, C.B.E., M.C., GENERAL SECRETARY, TRADES UNION CONGRESS, SMITH SQUARE, LONDON, S.W.1. J 959

AN ASSISTANT MECHANICAL ENGINEER is required for a medium/heavy engineering works near Leicester. Minimum educational requirements are, exempting qualifications for Graduate Membership of the Institute of Mechanical Engineers, and candidates should have had either works experience or post-graduate apprenticeships. Candidates, who should be between the ages of 24 and 28 years, are invited to submit brief details of their careers to date for consideration in the first instance by the CHIEF ENGINEER.—BOX J 983, Offices of ENGINEERING.

VACANCY FOR DRAUGHTSMAN.

Oil Company requires for London office

DESIGN DRAUGHTSMAN fully experienced Structural Steelwork, versatile and adaptable, some experience reinforced concrete foundations, etc., preferably aged 35 to 40 years. Salary according to age and experience. Pension Scheme, canteen facilities, social and sports club facilities. Please apply in writing to BOX ZP.270, DEACON'S ADVERTISING, 36, LEADENHALL STREET, E.C.3. J 984

JIG & TOOL DRAUGHTSMEN
DESIGN DRAUGHTSMEN

JOSEPH LUCAS LIMITED, BURNLEY,

Manufacturers of Aircraft and Motor Equipment.

Require capable ambitious men to assist in the work of **GAS TURBINE DEVELOPMENT.** Here is an opportunity for men with initiative to obtain a progressive position. The work is extremely interesting and demands a high degree of skill and ingenuity. A generous pension scheme provides an assured future, the working conditions are excellent and full restaurant services are provided. High salaries are paid to the right men.

Apply to :

The Personnel Manager, Hargher Clough Works, Burnley. J 868

THE CHEMICAL AND INSULATING CO., LTD., DARLINGTON, CO. DURHAM.

ENGINEER

required for planning new construction plant maintenance and preventive maintenance for a wide variety of mechanical and electrical plant in the chemical industry.

Applicants should be between 30-40, have good practical engineering experience and preferably be corporate members of a senior engineering institution or have equivalent qualifications.

The position is a progressive one with prospects, salary will be commensurate with responsibilities, and a contributory pension scheme is in operation.

Apply in writing giving details of education, experience and qualifications. K 30

ASSISTANT CIVIL ENGINEERS required for large Iron and Steel Works in the Midlands. Conversant in Building Construction, Reinforced Concrete Structures, Excavations and Foundations, Site Levelling and Setting-out, Preparing Scheme and Detail Drawings. Work is varied and covers a large field for experience. Applicants should hold a degree or be studying for same. Please state Age, Positions held and salary expected.—Apply in writing, to GENERAL MANAGER, IRON AND STEEL WORKS, CORBY, NORTHANTS. J 992

MECHANICAL ENGINEER required by International Group for work as Development Engineer in MIDDLE EAST Oilfields. Duties would include design work in connection with pumping, storage and loading of oil, transmission of natural gas, water storage, steam and diesel engine installations, industrial buildings, etc. Applicants should possess A.M.I.Mech.E. or equivalent, and have had several years experience on work described. Professional qualification not essential if engineering background otherwise satisfactory. Two year tour in first instance and substantial salary, payable also while on leave. Married accommodation and free family passages available. Write asking for application form and sending brief details of career to BOX E.6. 568, c/o 191, GRESHAM HOUSE, E.C.2. J 998

DEVELOPMENT ENGINEER required for mass production precision engineering works in North Midlands. The methods and processes are of a varied nature covering in the main, machining, grinding, assembly and inspection and the appointment is with a view to introducing new and improved methods on a high precision quality product.

Applicants, who should be about 35 years of age, must have had good technical and practical experience, possess initiative, discernment and have a flair for experimental work and investigation, will be given guidance and every assistance. Some knowledge of electricity desirable.

The position is permanent for a suitable applicant who should derive considerable satisfaction and interest from the work.

The Company is old established and operates a pension scheme.

Reply in confidence giving full particulars of experience, qualifications, salary required and age. No original testimonials please.—BOX K 1, Offices of ENGINEERING.

EXECUTIVE ENGINEER

required by

BRANDT & O'DELL,

CONSULTING ENGINEERS,

GROSVENOR GARDENS HOUSE,

VICTORIA, S.W.1.

Applicants to be not less than 35 years of age, Surveying, and Building in general. Capable of controlling and managing Field Teams and Drawing Offices. Excellent remuneration. Apply in writing in first instance giving full particulars and salary required. G 626

RESIDENT ENGINEER required on Tyneside for civil engineering and building work in shipyard reconstruction. Possibility of long term employment for man with good experience. Apply, stating age, qualifications and experience and salary required to BOX J 964, Offices of ENGINEERING.

PILKINGTON BROTHERS LIMITED, who are the largest manufacturers of plate and sheet glass in the British Commonwealth and employ more than 20,000 persons, wish to appoint a

HEAD OF THEIR TECHNICAL DEVELOPMENT DEPARTMENT.

This is a new appointment necessitated by the large number of development projects in hand. It is intended that the man selected should take charge of the development of new processes and the radical improvement of existing ones. There are ample technical resources available and the Company spends large amounts on development work. Applicants must have a good Honours Degree in engineering, physics or chemistry. They must also have a flair for development work, and the enthusiasm to see a job through. Applications will be welcomed from men aged preferably 35/45, who have done at least five years development work in industry or at a University. The Company is prepared to offer a Service Agreement on an attractive salary to the right man. The Company operates contributory Superannuation and Widows Pension Funds. All applications will be treated confidentially and should be addressed to the GROUP PERSONNEL OFFICER, PILKINGTON BROTHERS LIMITED, THE GLASS WORKS, ST. HELENS, LANCASHIRE. J 956

A PUBLICITY MANAGER

is to be appointed by an important firm in the field of building and engineering materials in the Manchester area. He should have experience of technical advertising and publicity in an industrial concern and be conversant with the preparation and supervision of printed matter, exhibitions, editorials, etc. Initial salary dependent upon age and capabilities but not less than £900 p.a. with every prospect of progressive advancement.—BOX J 962, Offices of ENGINEERING.

BRITISH THOMSON-HOUSTON COMPANY, LTD.

There is a vacancy in the Research Laboratory at Rugby for an

ENGINEER, qualified in either Electrical or Mechanical Engineering to H.N.C. level, preferably with some draughting experience, to assist in the Development and Engineering of Laboratory projects. Their wide variety demands a corresponding breadth of interests.

Applicants are invited to write to THE DIRECTOR OF RESEARCH, BRITISH THOMSON-HOUSTON CO., LTD., RUGBY, giving details of their age, qualifications, and experience, quoting reference GP. J 978

HAWTHORN LESLIE (ENGINEERS) LTD.,

ST. PETER'S WORKS, NEWCASTLE-UPON-TYNE.

HAVE THE FOLLOWING VACANCIES IN THE MARINE TURBINE SECTION OF THEIR DRAWING OFFICE:

SENIOR DRAUGHTSMAN

to take full charge of the turbine section of the Drawing Office, responsible only to the Chief Draughtsman—applicant must be fully experienced in the design and details of modern marine turbine propulsion machinery. Position would carry staff status.

DRAUGHTSMEN

previous experience in turbine detail work an advantage, but not essential.

Applicants should write to:—

THE CHIEF DRAUGHTSMAN

stating age, and full particulars of their technical and practical training and experience.

Starting salary according to qualifications and subsequent advancement on merit. Permanent positions. Staff Pension Scheme. K 11

AN ASSISTANT ELECTRICAL ENGINEER is required for investigating the electrical problems encountered in an integrated Iron and Steel Works possessing its own generation and distribution system.

Applicants should be graduates between 23 and 30 years of age.

Applications to:—

THE CHIEF ENGINEER,
WORKINGTON IRON & STEEL COMPANY,
MOSS BAY, WORKINGTON, CUMBERLAND.

Please mark your application "PERSONAL." J 986

TOOLROOM FOREMAN required for service Toolroom of large company engaged in light engineering in South Midlands. Applicants must have had at least 10 years practical experience excluding apprenticeship. First-class knowledge of grinding operations essential. Applicants with supervisory and administrative experience will receive preference. Established staff position carrying high salary, profit sharing and superannuation schemes.—Applications, giving full details to BOX J 970, Offices of ENGINEERING.

ENGINEER.

Experienced engineer required for a senior post on a large copper mine in Northern Rhodesia. Applicants should be between 30 and 40 years of age and should hold a B.Sc. Degree in Engineering or equivalent professional qualifications.

They should have had considerable practical experience, preferably in Mechanical Engineering in the mining field although experience in other branches of engineering will be considered.

Previous experience in an administrative or executive capacity is essential. Basic salary will depend on experience and qualifications. There is also a cost of living allowance currently £70 per annum, a bonus based on the prosperity of the industry and which is at present in excess of 70 per cent. of basic salary and a pension and life assurance scheme. A house with basic essential furniture is available at a nominal rental. Leave is at the rate of 55 days per annum and can be accumulated for three years. Free passages to Northern Rhodesia for successful applicant and family are provided. Reply giving details of age, experience, marital status, together with copies of testimonials, and a recent photograph to R.3 MINES EMPLOYMENT DEPARTMENT, SELECTION TRUST BUILDING, MASON'S AVENUE, COLEMAN STREET, E.C.2. J 974

GOSS PRINTING PRESS COMPANY LIMITED

have immediate vacancies for:—

RATEFIXERS
PROCESS PLANNING ENGINEERS

Applicants must have served a recognised engineering apprenticeship and have practical experience of Ratefixing and Process Planning in precision engineering. Generous superannuation scheme. Salary in accordance with experience and ability. Excellent prospects. Please supply full details of age, experience and qualifications to PERSONNEL MANAGER, GREENBANK STREET, PRESTON. K 36

ENGINEER required by large aluminium company in Birmingham area for interesting sales development work. Honours graduate preferred with structural and strength of materials background, age about 30. Excellent prospects for man with initiative. Salary according to qualifications and experience.—BOX K 42, Offices of ENGINEERING.

Leading manufacturers of container closures in the Midlands have a number of vacancies for ambitious **DESIGN DRAUGHTSMEN** preferably with some experience in this or a similar sphere. Interesting work with excellent salary and every opportunity for promotion to senior position in a rapidly growing organisation. Write in confidence with details of experience, positions held, salary required; to P. A. METAL CLOSURES LIMITED, BROMFORD LANE, WEST BROMWICH. G 627

SIMON-CARVES, MINING DIVISION, invite applications from

EXPERIENCED ENGINEERS capable of supervising the complete erection and commissioning of all types of colliery winding and surface equipment, to fill posts as Resident Site Engineers on large scale Colliery construction and reconstruction. Candidates must be qualified electrical and mechanical engineers with previous erection experience. Salary according to experience and qualifications plus adequate out allowance.—Apply stating age, experience, previous employers and quoting reference BU.4 to CONTRACT LABOUR OFFICE, SIMON-CARVES, LTD., CHEADLE HEATH, STOCKPORT, CHESHIRE. K 33

Expanding engineering company near Lake District offers good scope to

A DRAUGHTSMAN prepared to use initiative in the design and development of either coal mining machinery or earth moving machinery. Previous experience of these kinds of machinery is desirable but experience of medium or heavy general engineering may be acceptable. Good conditions. Pension scheme. Assistance with housing.—Apply DISTINGTON ENGINEERING COMPANY LIMITED, P.O. BOX 8, WORKINGTON, CUMBERLAND. K 13

TANGYES LIMITED.

GENERAL WORKS MANAGER. The Company wish to appoint a Senior Executive Engineer, who, having proved himself suitable, will be capable, after a period, of taking over the general control of the Works including large iron foundry on the retirement of the present General Works Manager. Applicants should have wide experience of modern machining and assembly methods, Planning and Time Study for both batch and one-off production and labour control. Iron Foundry experience an advantage. The position offers excellent prospects. Pension Scheme available. Applications, which will be considered in strict confidence, must give details of Technical and practical training, past employment, age, etc., to be addressed to the ASSISTANT MANAGING DIRECTOR (ADMIN.) TANGYES LIMITED, CORNWALL WORKS, SMETHWICK, BIRMINGHAM. K 26

TECHNICAL LIAISON

THE GUEST KEEN & NETTLEFOLDS GROUP RESEARCH LABORATORY

has an opening for

QUALIFIED MEN to be engaged on technical liaison work between the laboratory and production units in the group. An important part of the duties will be those of technical secretaries, and in addition to a degree or equivalent qualification, preferably in Engineering or Metallurgy, applicants should have some experience of work in industry and be competent to convey information by both the written and the spoken word. Applicants should be between 25 and 35 years of age and should write, giving full details of experience, to the Director of Research, G.K.N. Group Research Laboratory, Birmingham New Road, Lanesfield, Wolverhampton. All communications to carry reference number L.I.1. J 975

IMPERIAL CHEMICAL INDUSTRIES LIMITED

ALKALI DIVISION

WINNINGTON, NORTHWICH, CHESHIRE.

INSTRUMENT RESEARCH
and
DEVELOPMENT

Vacancies exist for staff to fill interesting and progressive positions of an engineering character in the application and development of instruments. The work, apart from improvement to existing instruments and the development of new instruments, will be largely concerned with the study of existing and new chemical plants and the best use of instruments on such plants.

Candidates, age 26-38, should have an honours degree in mechanical engineering, electrical engineering (or electronics), chemical engineering, physics or mathematics. Previous industrial experience will be an advantage.

Pension and Profit-Sharing Schemes. Married men may receive limited assistance with removal expenses. Apply to STAFF MANAGER, for application form quoting GES/INST. K 37

Classified Advertisements continued on Page 8

A FUTURE WITH FORD.

Our Power Services Department have a vacancy for a Mechanical Engineer. He must have Power Station administrative experience plus a knowledge of the installation and maintenance of large E.H.P. Boilers, Turbo Alternators and Auxiliary Plant. Should be young and forward looking with a taste for development work. Importance will be attached to technical education, details of which should be stated. Initial salary in accordance with experience and qualifications. From Pay to Pension, Ford is in the first flight.—You are invited to reply to SALARIED PERSONNEL DEPARTMENT, FORD MOTOR COMPANY, LIMITED, DAGENHAM, ESSEX, quoting reference MEP. J 896

DRAUGHTSMEN (SENIOR AND JUNIOR) required for work in connection with the following branches of Coke Oven and Gasworks plants.

(*a*) Mechanical and By-Product Plant.
(*b*) Pipework.
(*c*) Steelwork for Buildings and Conveyors.

Applicants should be competent men able to work with the minimum of supervision. Technical qualifications to O.N.C. or beyond. Good remuneration and prospects for capable men. Pension scheme. Five-day week; Canteen Facilities.—State age and experience to the PERSONNEL OFFICER (D.O.), WOODALL-DUCKHAM CONSTRUCTION COMPANY LTD., WOODALL-DUCKHAM HOUSE, 63-77, BROMPTON ROAD, LONDON, S.W.3. G 550

Seventy-five pounds per month and upwards according to experience offered for **EXPERIENCED DESIGNER** in R.C. as applied to commercial buildings. Pension scheme and a permanent position with an old-established company in their London Head Office. Five-day week. A vacancy also exists for Designer/Draughtsman working under Senior Designer with salary from £50 p.m.—Reply BOX G 587, Offices of ENGINEERING.

WANTED

DRAUGHTSMEN to design in aluminium for sales development. Must possess Higher National Certificates in Mechanical Engineering. Location Banbury. Good working conditions and pleasant surroundings. Attractive starting salaries offered up to £800 p.a. with prospects of promotion from drawing board. Pension plan in operation. Send brief details of qualifications and experience to NORTHERN ALUMINIUM CO. LTD., BUSH HOUSE, ALDWYCH, LONDON, W.C.2. G 562

West End London Consulting Engineers require now **SEVERAL SENIOR AND JUNIOR ENGINEER DRAUGHTSMEN** to prepare designs, contract drawings, specifications, etc., for heating, ventilating, boiler plant and allied mechanical services. Interesting work for factories, office blocks, hospitals, colleges, schools, etc. Opportunity for experienced men with initiative. Five-day week. One week's spring holiday in addition to usual summer two weeks. Bonus and optional superannuation scheme.—Write stating age, experience, qualifications and salary required. BOX G 538, Offices of ENGINEERING.

CHIEF TEST ENGINEER required for special and routine testing in Hydraulic Transmission Department. This new post requires close collaboration between Works and Drawing Office in connection with the reconciliation of manufacturing and design problems. Degree standard and some turbine or centrifugal pump experience required. This senior staff appointment is superannuated.—Apply confidentially, stating age, experience and qualifications to GENERAL MANAGER, NORTH BRITISH LOCOMOTIVE CO., LTD., SPRINGBURN, GLASGOW, N.1. J 881

A SENIOR INVESTIGATOR is required to direct the activities of a group of people engaged in applied research into metallurgical problems connected with the rolling, extrusion and forging of aluminium alloys. Familiarity with works processes and some research experience would be a decided advantage. The salary will be attractive and in accordance with age and experience. A pensions scheme is in operation.—Apply to: THE DIRECTOR OF RESEARCH, ALUMINIUM LABORATORIES LIMITED, BANBURY, OXON. J 774

PETER BROTHERHOOD, LTD., Peterborough, require

DRAUGHTSMEN (SENIOR AND JUNIOR) preferably with experience in design of compressors turbines and steam engines. Permanent positions, five-day week, staff pension scheme.—Write, giving full details age, experience and salary required. Z 426

Opportunities in
LOW TEMPERATURE ENGINEERING.
Applications are invited for appointment as

DEVELOPMENT ENGINEERS

to undertake interesting projects, involving thermodynamics, heat transfer distillation, and covering the technical design and operation of plants. The projects are concerned with the production and distribution of oxygen, nitrogen and argon as gases or liquids.

Applicants should hold an Honours Degree.

For people joining the Company from outside the North London area, it is of interest that the Works is within easy travelling distance of North London residential areas, verging on the Green Belt of Middlesex and Hertfordshire, and on Epping Forest. FULL ASSISTANCE TOWARD THE PURCHASE OF HOUSES WILL BE GIVEN TO SELECTED APPLICANTS AND REMOVAL AND LEGAL EXPENSES PAID.

Applications, giving fullest possible information of qualifications and experience to :—

The Personnel Manager,
BRITISH OXYGEN ENGINEERING, LTD.,
ANGEL ROAD, UPPER EDMONTON,
LONDON, N.18. J 846

A WORKS MANAGER with a sound engineering training and experience in up-to-date methods of production and control is required at the North-East Coast Factory of a well-known Company.

The successful applicant will be a man of strong personality and exceptional qualities who can ensure economical production in a medium size factory embracing machining, light and heavy assembly and electrical work.

A starting salary of not less than £1500 is envisaged and prospects are excellent. There is a Pension Fund in operation and assistance will be given with housing if required.

Write giving full details including age, previous experience and salaries earned to BOX J 941, Offices of ENGINEERING.

ASSISTANT ENGINEER, AGED 25/30 required to assist Engineer and Buyer. Qualifications B.Sc. or equivalent with two years' student apprenticeship. Duties will include visiting manufacturers' works and may lead to an interesting and well paid post overseas. Commencing salary in U.K. £800 to £1100, according to age and qualifications.—APPLY THE BRITISH PHOSPHATE COMMISSIONERS, 2, GROSVENOR GARDENS, LONDON, S.W.1. K 39

DRAUGHTSMEN

STEWARTS AND LLOYDS, LIMITED

require Draughtsmen immediately for the design and layout of pipework for major power-plant schemes. Previous experience on pipework not essential but knowledge of power stations or similar installations desirable. The possession of Higher or Ordinary National Certificates an advantage. Vacancies exist in Birmingham and Wednesbury.

Pensionable posts and good salaries available to those who prove themselves qualified.

Reply to SECRETARY, STEWARTS AND LLOYDS, LIMITED, BROAD STREET CHAMBERS, BIRMINGHAM, stating age, experience and salary required. J 890

A Public Company require the services of an **ENGINEER GRADUATE.** The situation is the first of its kind, and the work on which the successful applicant would be engaged would be very varied. Qualities such as personality, versatility and adaptability against a broad scientific education with some practical experience would meet our requirements.—Apply BOX J 928, Offices of ENGINEERING.

B.I.P. CHEMICALS LIMITED, OLDBURY, have a vacancy for a **DRAUGHTSMAN** for Chemical Plant layout and detailing. Knowledge of building and plant structure work and services necessary. Applicants should possess National Certificates.—Write giving full particulars of age, experience and posts held to the PERSONNEL MANAGER, B.I.P. CHEMICALS LIMITED, OLDBURY, BIRMINGHAM. J 948

ENGLISH ELECTRIC CO. LTD.,

METER, RELAY AND INSTRUMENT DIVISION, STAFFORD.

SPECIALIST TOOL DESIGN ENGINEER.

A new key appointment is to be made for a top-grade engineer with considerable experience of increasing productivity, by the use of up-to-date automatic and semi-automatic tooling techniques, to be applied to high quantity production of precision components for Meters, Relays and Instruments. Previous experience of these particular products not essential.

The post is permanent, progressive and pensionable and at an appropriately high salary level. A house will be made available to the successful applicant.

Applications should contain complete personal background and will be accorded strict confidence. APPLY TO DEPT., C.P.S. 336/7, STRAND, W.C.2, QUOTING REF. 1170C. J 934

Consulting Engineers, Westminster, require **ASSISTANT** experienced in the design and/or detailing of reinforced concrete bridges. High salary, interesting work and excellent prospects. Write stating age, qualifications and full details of experience.—BOX J 822, Offices of ENGINEERING.

IMPERIAL CHEMICAL INDUSTRIES LIMITED, BILLINGHAM DIVISION, require an **EXPERIENCED METALLURGIST** for work in the Division Metallurgical Laboratories. The work is varied and deals with the wide range of metallic materials and fabrication processes used in the erection and maintenance of many chemical processes.

The man appointed will be required to assist in the diagnosis of equipment failures and will be expected to undertake original research work; encouragement is given for publication of papers based on such work.

The Division's metallurgists are in regular contact with Research Associations and other industrial laboratories; they also maintain contact with contractors engaged in work for the Division.

Candidates should be in the age group of 30-35, should have a good degree in metallurgy and several years' experience in industry, preferably in a branch of the metal or equipment producing industries. The appointments are permanent and pensionable. Attractive salaries are offered and assistance can be given towards house purchase.

Write, giving full details of age, qualifications and experience to the STAFF MANAGER, IMPERIAL CHEMICAL INDUSTRIES LIMITED, BILLINGHAM, CO. DURHAM, quoting reference T.5. K 2

A TRAINING ASSISTANT is required by a large Iron and Steel Company to augment, in a junior capacity, the staff of the Training Officer at Hilston, Staffordshire. His duties will be partly administrative, partly instructional and will cover the industrial training and education of adults and juniors. Some knowledge of and preferably practical experience in metallurgy and/or engineering are required. An additional desirable qualification is experience in teaching and/or youth work. Living accommodation cannot be provided by the Company. Application form, to be returned within two weeks of the appearance of this advertisement, will be forwarded on request to BOX K 31, Offices of ENGINEERING.

METHODS ENGINEER required for Assembly, preferably with Planning experience on I.C. Engines. O.N.C. minimum qualification. Permanent position. Apply, PERSONNEL MANAGER, F. PERKINS LTD., PETERBOROUGH. K 33

Draughtsmen, Draughtswomen and Tracers — Mechanical Engineering.

For Engineering Consultants. Positions are permanent, pensionable, with five-day week. Free lunches. Basic Salary above A.E.S.D. minimum rates, plus profit sharing scheme.

Phone or write, giving details of previous experience, to the

PERSONNEL OFFICER, EWBANK & PARTNERS, LTD., 10/11, GROSVENOR PLACE, LONDON, S.W.1. 200 YARDS HYDE PARK CORNER. SLOANE 0486. G 630

CIVIL ENGINEERING DRAUGHTSMAN required by Consulting Engineers for work in Edinburgh. Post carries staff pensions assurance. Technical education on H.N.C. course basis advantageous but not essential. Preference for experience either in structural steel or reinforced concrete.—BOX G 524, Offices of ENGINEERING.

DESIGNER-DRAUGHTSMEN
and
DETAIL DRAUGHTSMEN
With Crane or Structural Experience
required by
COWANS, SHELDON & CO., LIMITED,
of Carlisle.
Good Commencing Salary and Pension Scheme. G 622

CIVIL ENGINEERING ASSISTANTS required for work in Scotland by Consulting Engineers:

(*a*) A.M.I.C.E. or similar standard for either design or site supervision.
(*b*) Graduates who desire opportunity to complete requirements for A.M.I.C.E.

In both cases immediate posts are in Scotland but positions are long term and carry staff pensions assurance and opportunities where desired for work in London and abroad later.—BOX G 525, Offices of ENGINEERING.

POWER STATION SUPERINTENDENT.

Required for modern industrial station with pass-out Turbo-Alternators providing steam and energy for a large continuous process plant, present capacity 7,500 kW. and process steam 100,000 lbs. per hour, shortly to be increased. Candidates should be Corporate Members of the Institution of Mechanical and/or Electrical Engineers, or possess equivalent qualifications and have had previous experience in a similar capacity including maintenance of Station. Operational experience with High Pressure (1,000 lbs. per square inch) Boilers and Turbines in stations of similar, or larger, capacity an advantage. Very good salary with permanent and progressive position for first-class man who has the right experience and qualifications. Age 35-50. Pension Scheme, possible assistance with housing. Applications which will be treated in confidence, should state age, qualifications, experience and present remuneration and be addressed to PERSONNEL MANAGER, BRITISH ENKA LIMITED, AINTREE, LIVERPOOL, 9. J 995

BRITISH PETROLEUM COMPANY LIMITED requires an

INSTRUMENT ENGINEER to supervise the installation, operation and development of instruments and automatic control equipment in the Company's refineries. Applicants should hold H.N.C. and should possess a thorough knowledge of pneumatic and electronic process control instruments with field experience in the process industries preferably in a supervisory capacity. Salary according to age, qualifications and experience. Non-contributory Pension Scheme. Luncheon Club. Write giving full details quoting H.3451A TO BOX 8506 c/o 191, GRESHAM HOUSE, LONDON, E.C.2. K 50

QUANTITY SURVEYOR required by Consulting Engineers in Birmingham. Staff pension scheme. Please reply in confidence giving qualifications, previous experience, age, etc., to BOX No. 295, GLOVERS ADVERTISING LIMITED, 351, OXFORD STREET, LONDON, W.1. G 586

Classified Advertisements continued on Page 92

Clyde SOOT BLOWERS
BOILER AVAILABILITY INCREASED
ELECTRO-MECHANICAL OPERATION with SEQUENCE CONTROL

IMPROVEMENTS OVER MANUAL OPERATION

1 No physical exertion required.

2 Soot blowing carried out in a quarter of the time.

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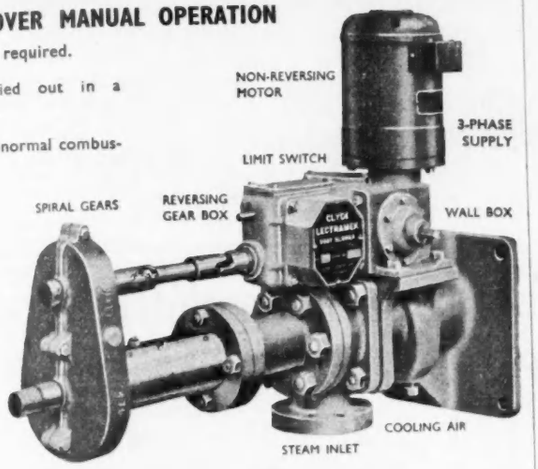
4 Cleaner heating surfaces with higher and sustained rate of evaporation.

5 Saving in fuel and labour costs.

6 Increased boiler availability.



London:—
34, VICTORIA ST., S.W.1
Telephone: ABBey 1847

Manchester:—
1, CHANCERY LANE, SPRING GARDENS, 2
Telephone: DEAnsgate 4262
Telegrams: "MURWILS"

CLYDE BLOWERS LTD

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TELEPHONE: CLYDEBANK 1576/77 TELEGRAMS: "MURWILS," GLASGOW

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Brown Brothers & Co. (Clydebank), Ltd.
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revolutionary industrial filtration

How many drops do you lose..
in a year?

FILTRALL
saves
the last drop

No statistician can calculate coolant wastage *to the last drop*, to ensure the maximum saving install the latest SWALES FILTRALL and test recovery over a period in your own machine shop - observe increased production and the relevant savings in wheel and diamond life.

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C. A. SWALES (FILTERS) LIMITED
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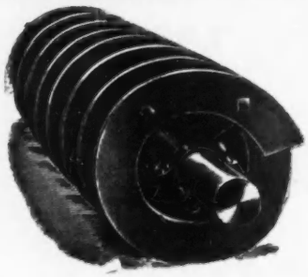
Telephone:- Dunstable 277

CONVEYOR AND ELEVATOR Co (1936) LTD.



BULL BRIDGE WORKS,
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Telephone No. 2779.
Telegrams: "Conveyor" Accrington.

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'I won't stand any slackness'
said the
KOLOK Positive
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Yes, Kolok washers are the answer to loose nuts and bolts. Fit them once and your troubles are over. Available in all sizes.

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45 RENFREW STREET, GLASGOW, C.2. · DOUglas 9292

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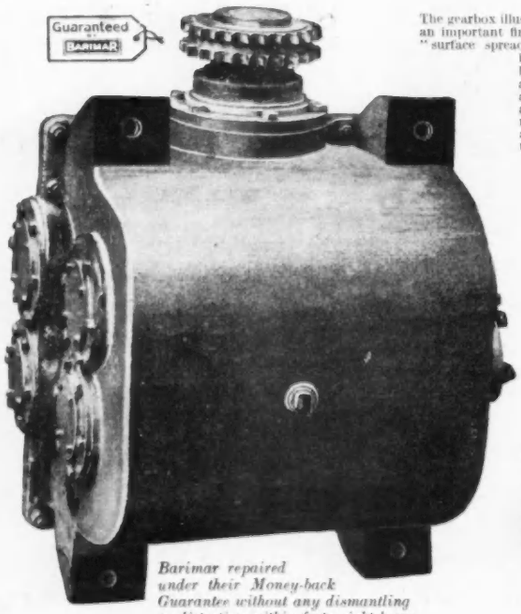
BUT...

BARIMAR makes a First-Class job without Distortion!

THERE ARE TIMES when dismantling of damaged machinery must prove difficult and complicated. The internal set-up of some apparatus is so complex that dismantling becomes a major operation.



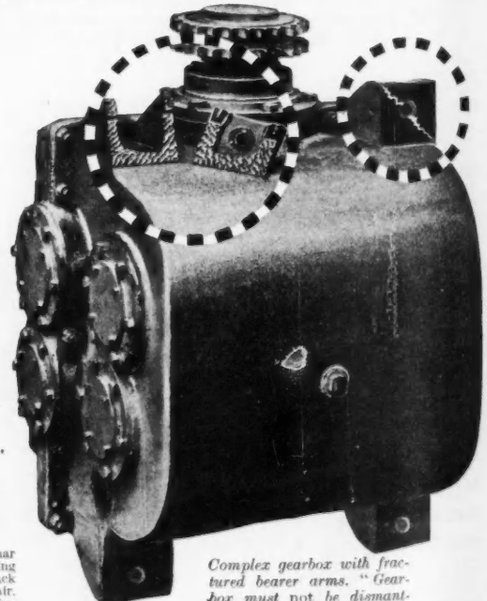
Barimar repaired under their Money-back Guarantee without any dismantling or distortion within forty-eight hours.

The gearbox illustrated is a vital part of a machine owned by an important firm of civil engineers. It was employed for "surface spreading." One of the comparatively small bearer arms was severed, and another was badly cracked. But—there was a "but" about this particular job—the internal arrangement of the gearbox was so complex and dismantling would have involved so much time and expense, that Barimar was asked to tackle the damage without taking the gearbox to pieces.

Within 48 hours this "ticklish" assignment was completed in the Barimar London works without dismantling or the slightest distortion.

Barimar are proud of the job, and so are the owners, for the work involved a minimum disorganization of their important schedule, plus a guaranteed money-back repair.

Whether repairs are carried out in a Barimar Factory or completed by a Barimar Flying Squad on the site, the usual Money-Back Guarantee accompanies every Barimar repair. Generally speaking, dismantling of machine parts before repair is preferable. But when serious objections to dismantling arise, Barimar experts are ready, at short notice, to go to any part of the British Isles. A 'phone call is all that is necessary.



Complex gearbox with fractured bearer arms. "Gearbox must not be dismantled"—said the owners.

ALL BROKEN PARTS which are transportable must be sent CARRIAGE PAID or delivered by customer. Please remove all fittings (unless prior arrangements made to contrary), and post letter advising dispatch.

BARIMAR

Barimar House, 22-24 Peterborough Road, FULHAM, LONDON, S.W.6
Telephones: RENown 2147-2148. Night 2148.
Telegrams: "Bariquamar, Walgreen, London."

BIRMINGHAM, 12: 116-117, Charles Henry Street.
Telephone: Midland 2696.
MANCHESTER, 13: 67 Brunswick Street, Ardwick.
Telephone: Ardwick 2738.
NEWCASTLE UPON TYNE, 1: 64-66, The Close.
Telephone: 21055.
GLASGOW, C.2: 134, West George Lane.
Telephone: Central 4709.

BARIMAR—THE WORLD'S SCIENTIFIC WELDING ENGINEERS

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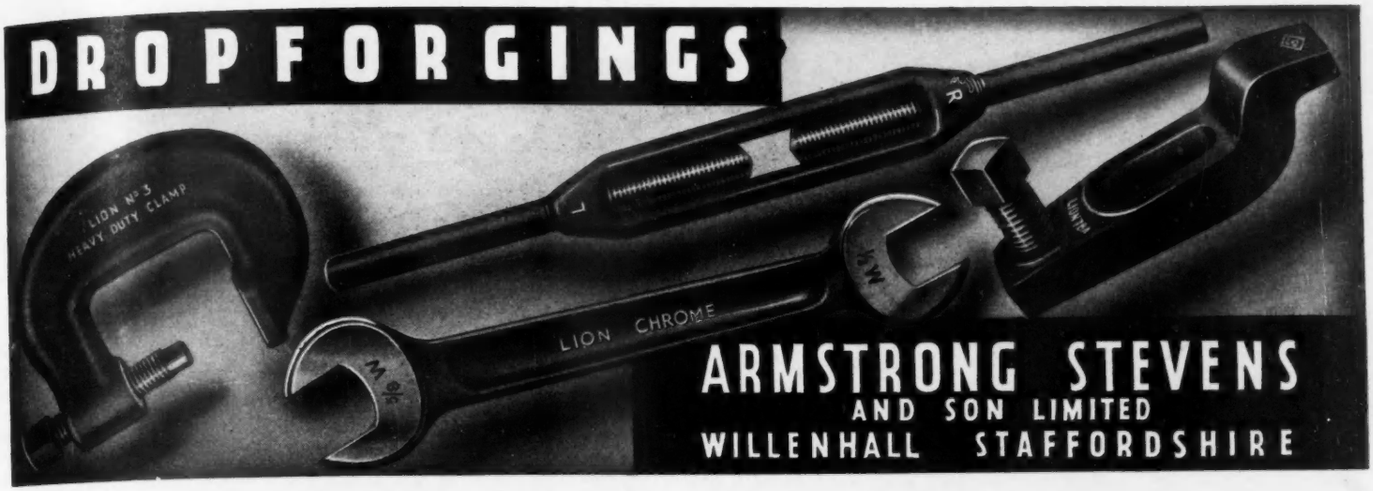

ARMSTRONG STEVENS
AND SON LIMITED
WILLENHALL STAFFORDSHIRE

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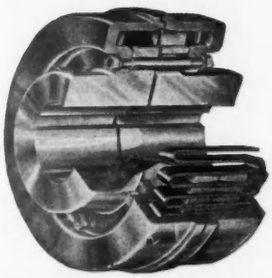
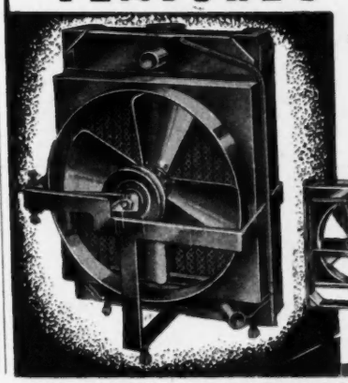


THE WELLMAN BIBBY CO. LTD.
PARNELL HOUSE, WILTON ROAD, LONDON S.W.1

DISTINCTIVE FEATURES of SERKOOL RADIATORS



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Belt Adjusting Device can be operated without stopping the engine. Felt Lining attached to the Cowl ensures proper Fan Suction and eliminates metallic vibration and noise.

Cooling Element removed by releasing two bolts. Write for full particulars and descriptive leaflet.

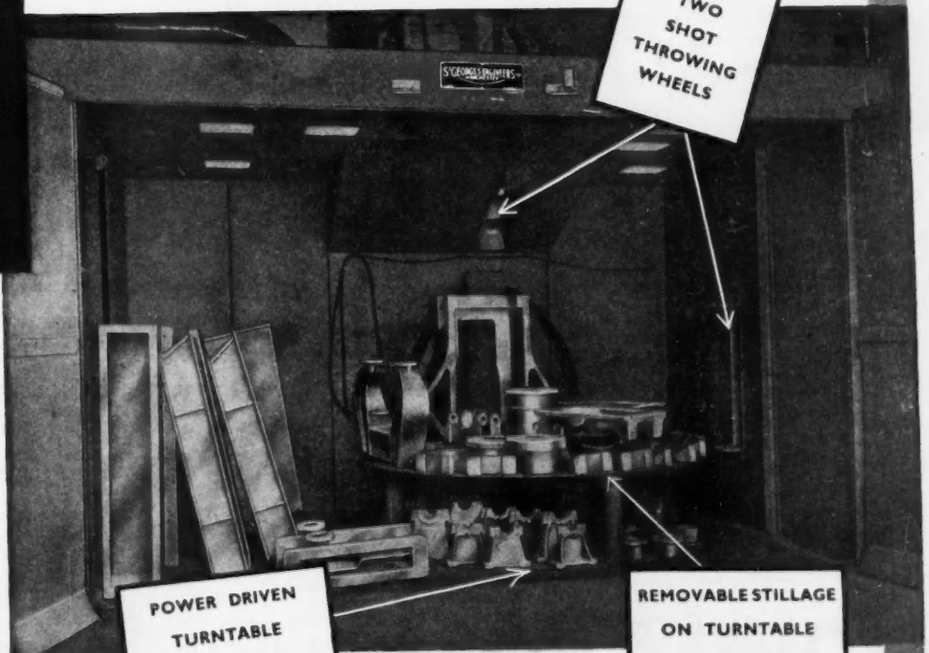
H. O. SERCK LTD
Sunlight Works, Derby Street, Oxford Road, MANCHESTER, 15
'Phone: Ardwick 2776 (3 lines)
Telegraphic Address: "SERCKRAD."

'UNIVERSAL' WHEEL BLAST ROOM PLANT
14'0" x 10'0" x 8'6"

comprising

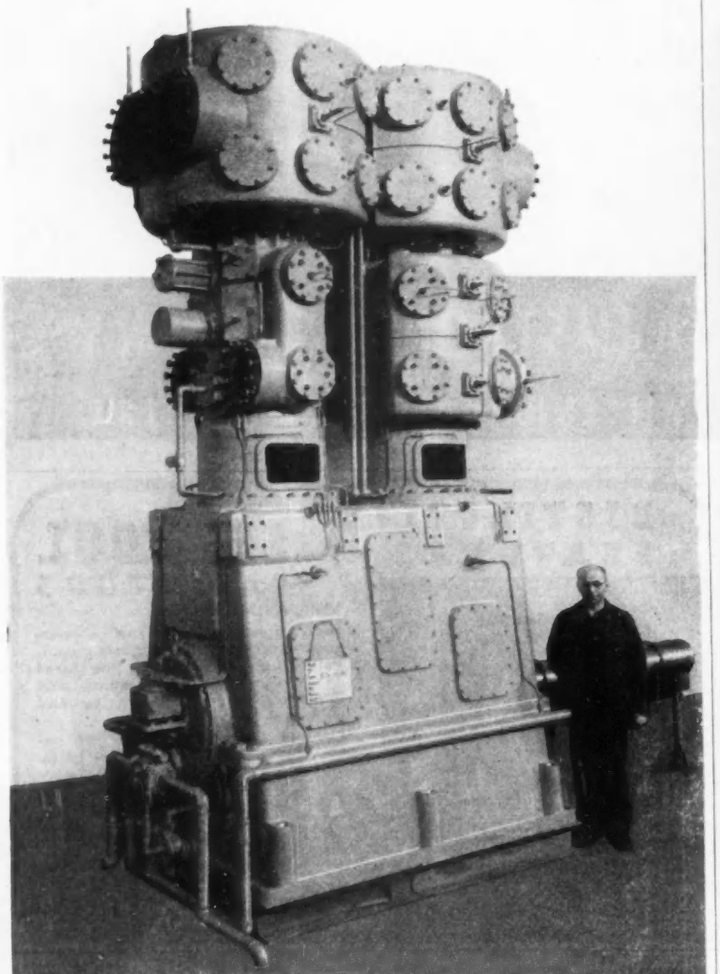
TWO SHOT THROWING WHEELS WITH PRESSURE NOZZLE FOR SPECIAL WORK

Made for Messrs. **HEENAN AND FROUDE, LTD. OF WORCESTER,** this plant is designed to accommodate all types of miscellaneous castings, welded fabricated work, and large steel tanks.



ST. GEORGES ENGINEERS LTD.

ORDSALL LANE, MANCHESTER 5
Telephone: TRAfford Park 1207 (4 lines). *Telegrams: "Georgic" Manchester 5*



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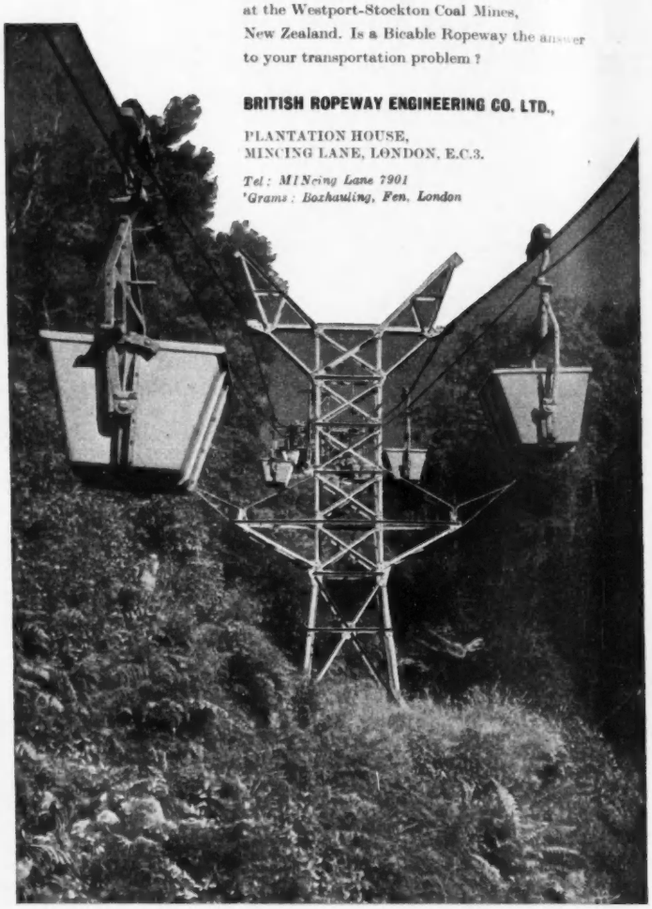

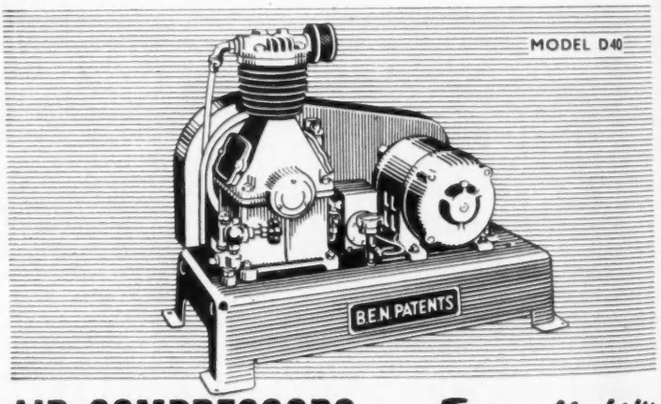

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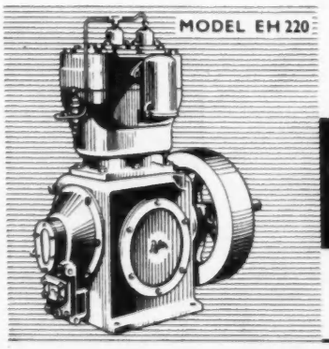

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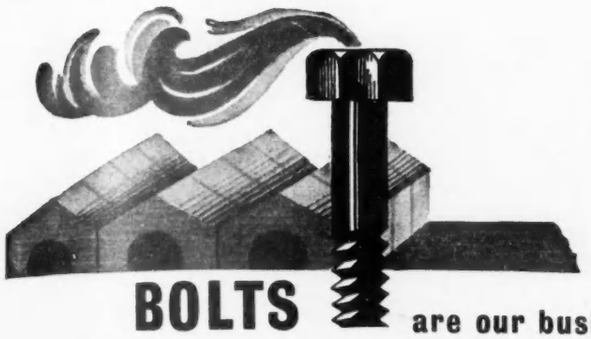

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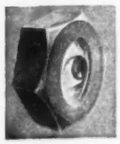

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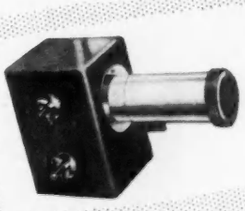

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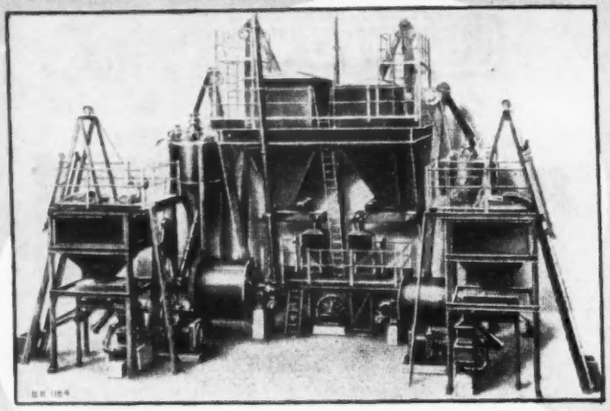

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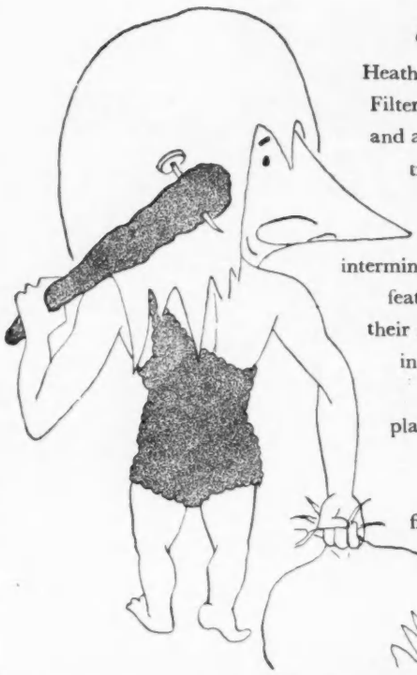
back to nature...



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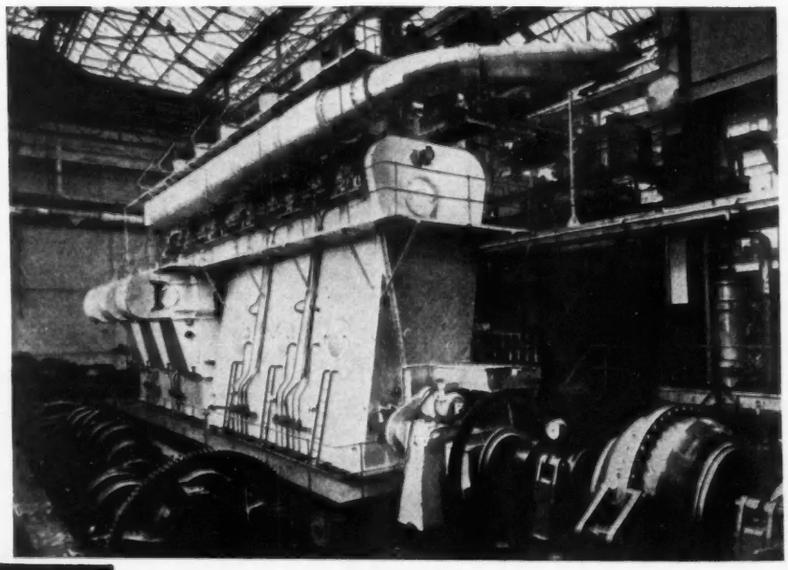

DOXFORD DIAPHRAGM ENGINE ON TEST.
The photograph was taken whilst the engine was running at 103 r.p.m. and developing 7750 b.h.p.

DOXFORD

diaphragm engine

Crank Case Isolation against corrosion.
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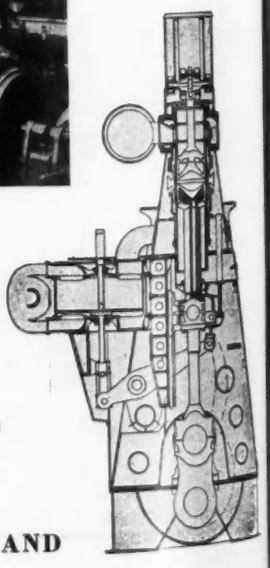

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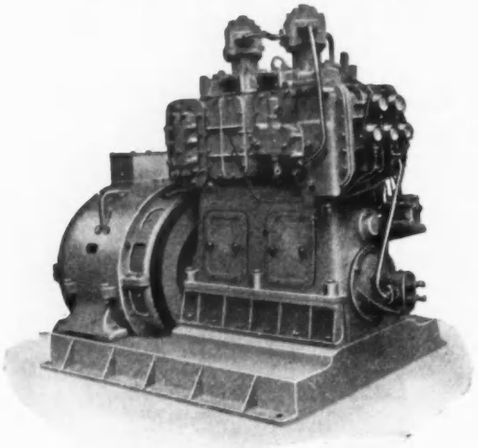
AIR COMPRESSORS for DIESEL SHIPS



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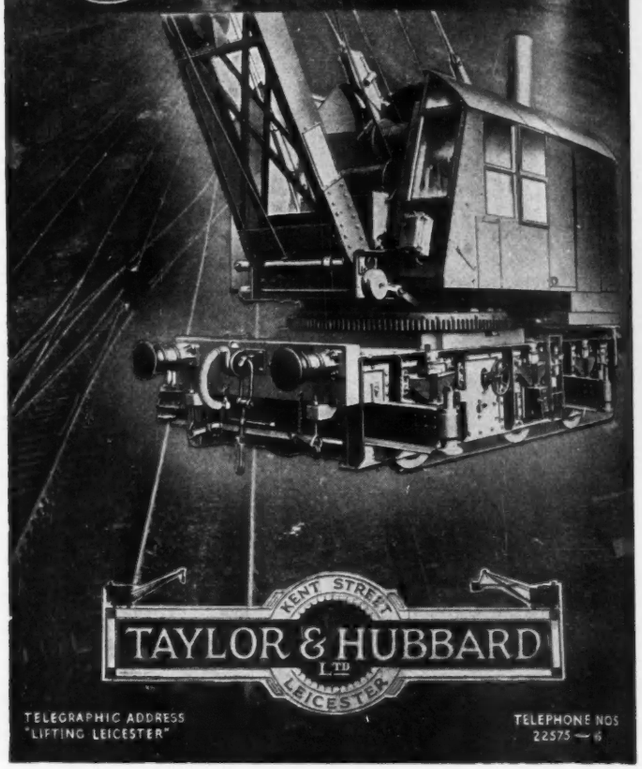

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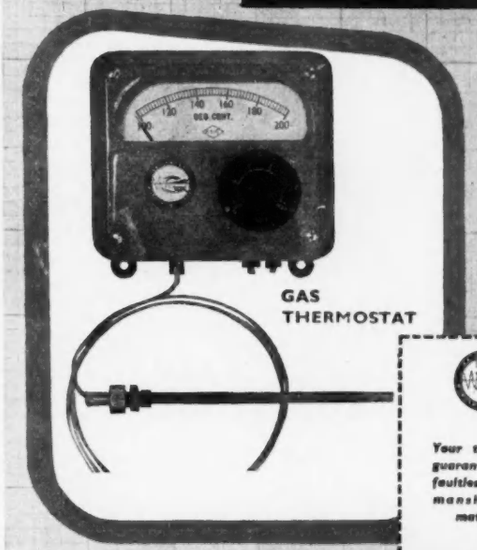

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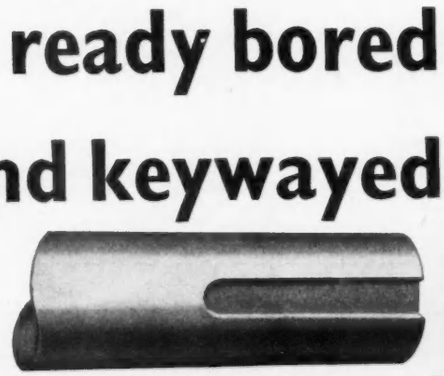

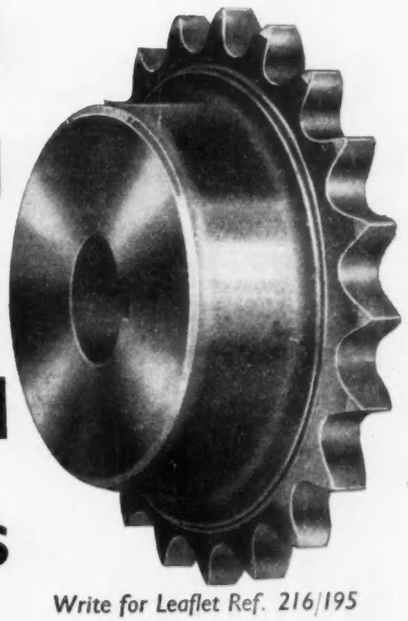

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	19	·75	·1875
	21	1·0	·250
	25		
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	21	1·0	·250
	23	1·125	·3125
	25	1·25	·3125
·75 (No. 110 066)	19	1·0	·250
	21	1·25	·3125
	23	1·5	·375
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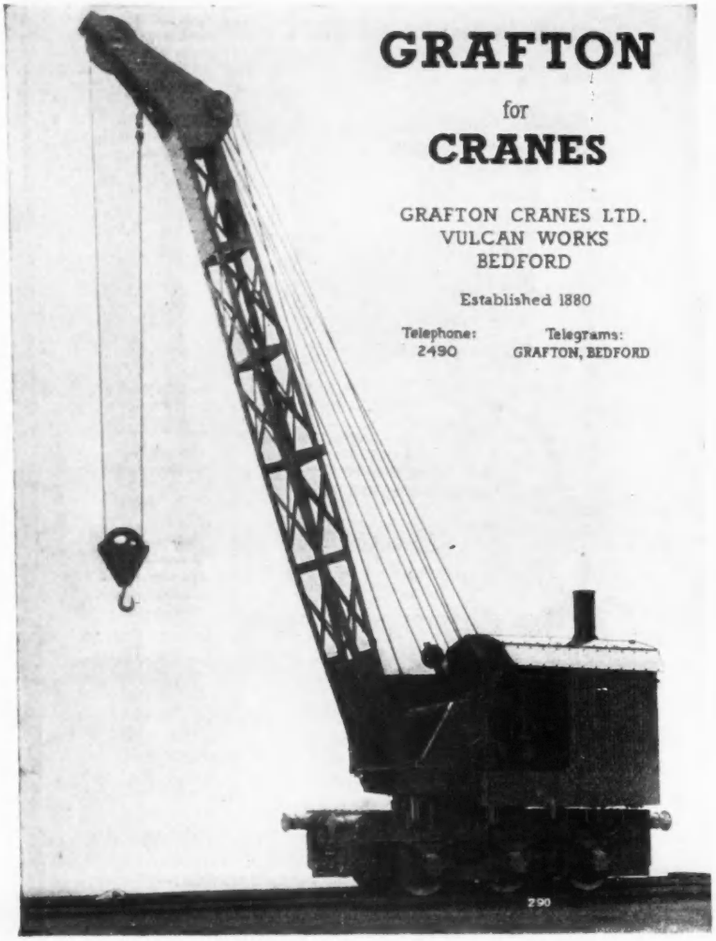

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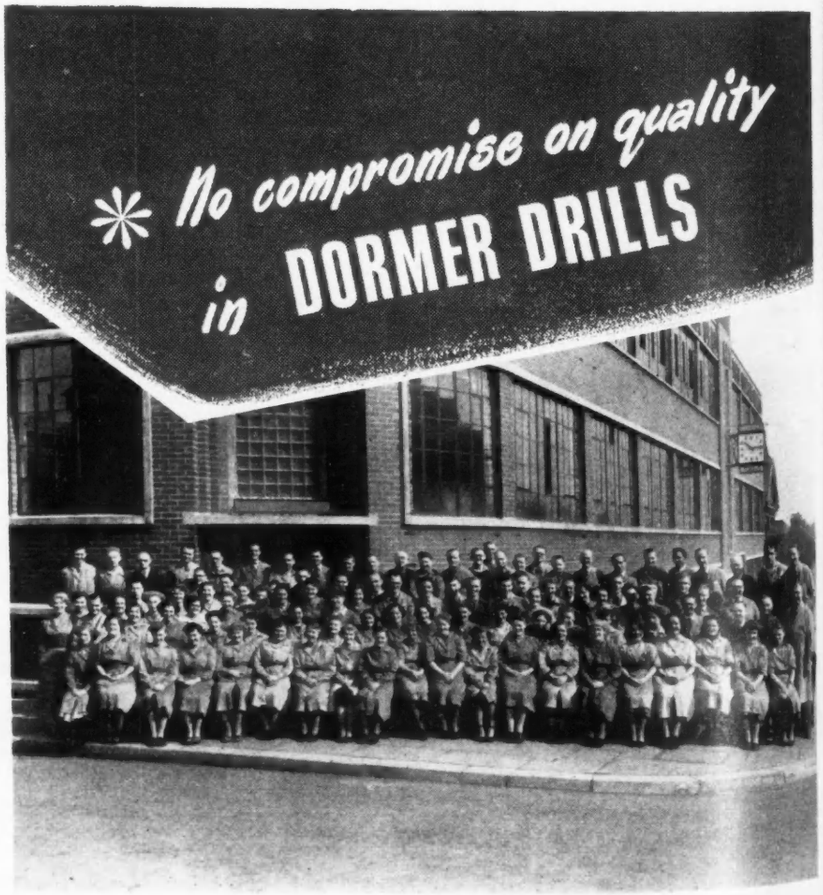

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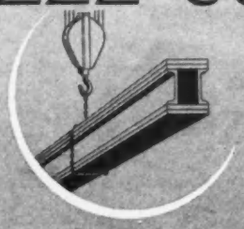

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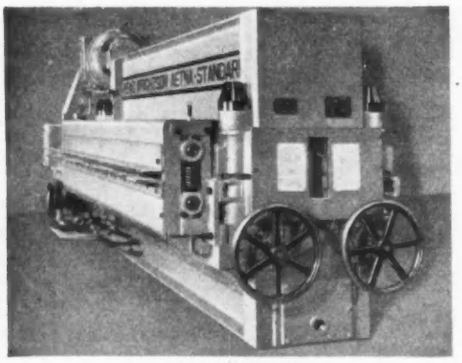
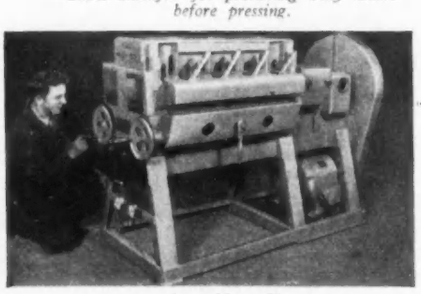


2½" x 2½" x 102"
Sheet Rectifier for processing body sheets before pressing.



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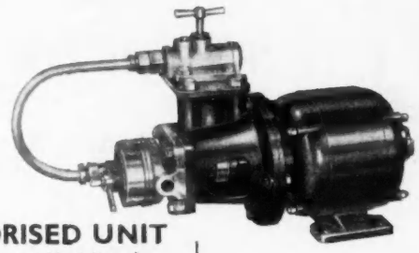

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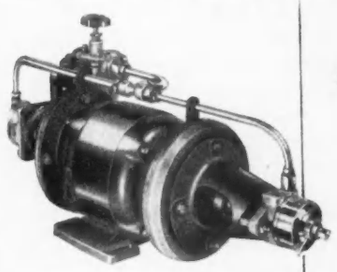

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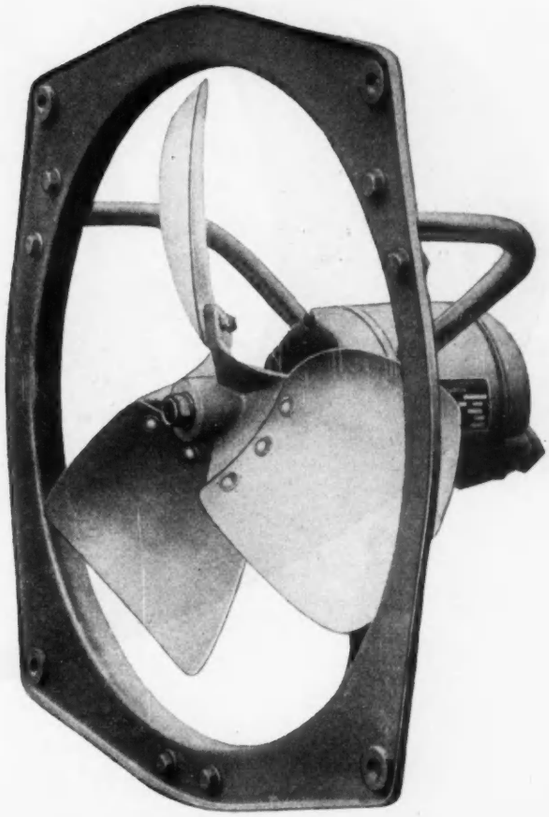

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ONLY THREE BLADES

These fans are included in our large range of stock machines which are always available.

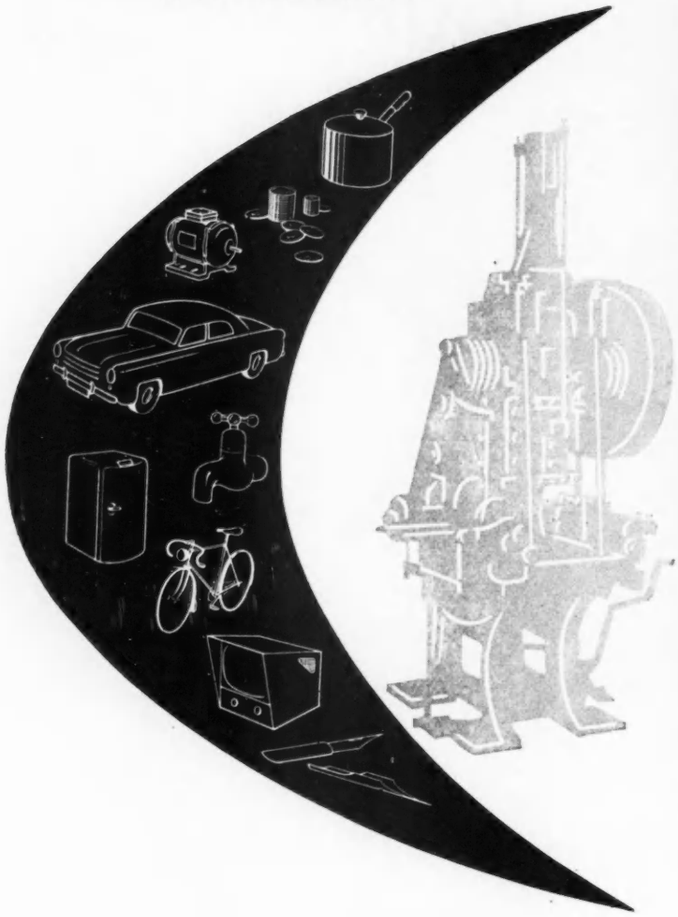
Write now for the newly published BOOKLET No. 32/2 giving full details of the APA range.

KEITH BLACKMAN LTD

Mill Mead Road · London N17

TP 7949/648

Pressure brought to bear



To make almost anything, if it is made from sheet metal or metal billets (hot or cold) or powdered metal, the simplest and most efficient method is to produce it with a Power Press; if the Press is fitted with automatic feeds for handling the material the production will be enormous. From experience we know that every Pressing problem needs special modifications according to specific requirements. However, we invite you to send for our set of catalogues which are completely descriptive and which illustrate both our range and our capacity. From them you may find the type of machine from which your own might be developed.

PDPMDA MEMBER

TAYLOR & CHALLEN LTD

BIRMINGHAM 19

INSULATION INVESTMENT begins with Newalls

ALL OVER THE COUNTRY our contracting staffs, working from 8 major depots in the main centres, are at work. A power station on the North East Coast . . . a cold store in Glasgow . . . a chemical works in South Wales . . . an industrial boiler installation in the Midlands . . . these are typical contracts. The men on the job are employing first rate materials — Newalls insulation specialities, which are manufactured to cover all temperature ranges from minus 300°F up to over 2,000°F. But they bring more than such materials to the job. Newalls make a point of studying the factors affecting the application of their materials, so that performance of the insulation has already been pre-determined before the contract has been started. This, coupled with a background of thousands of completed contracts using all types of insulation, adds up to an experience which supplements and transcends designs and specifications.

Good thermal insulation *is* an investment — that's why so many organisations, large and small, turn to Newalls for technical advice and consultation.

Where there's a problem of HEAT INSULATION there's a job for

Newalls

NEWALLS INSULATION CO. LTD. *Head Office:* WASHINGTON, CO. DURHAM

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Offices and Depots at LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE, BIRMINGHAM, BELFAST, BRISTOL & CARDIFF. *Agents and Vendors in most markets abroad.*

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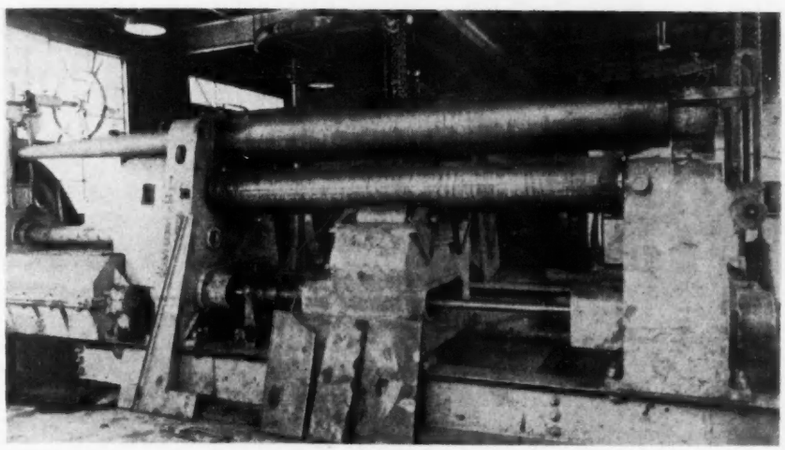
Specialists in bending

FABRICATION OF INDUSTRIAL PLANT IN MILD STEEL, STAINLESS, MONEL, INCONEL, NICKEL, AND CORRONEL B.

We can handle capacities up to 20 tons

PLATE BENDING & ROLLING — 8 ft. × 1 in. thick



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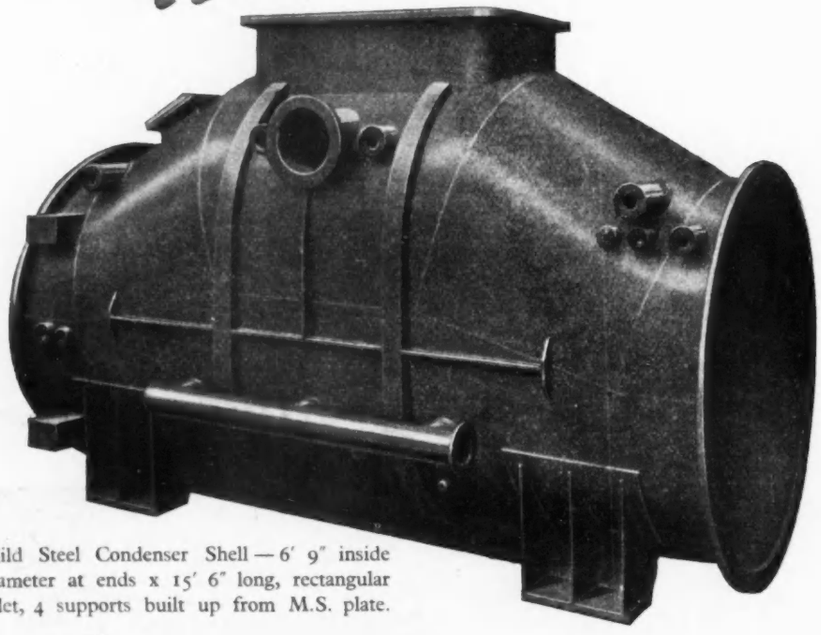
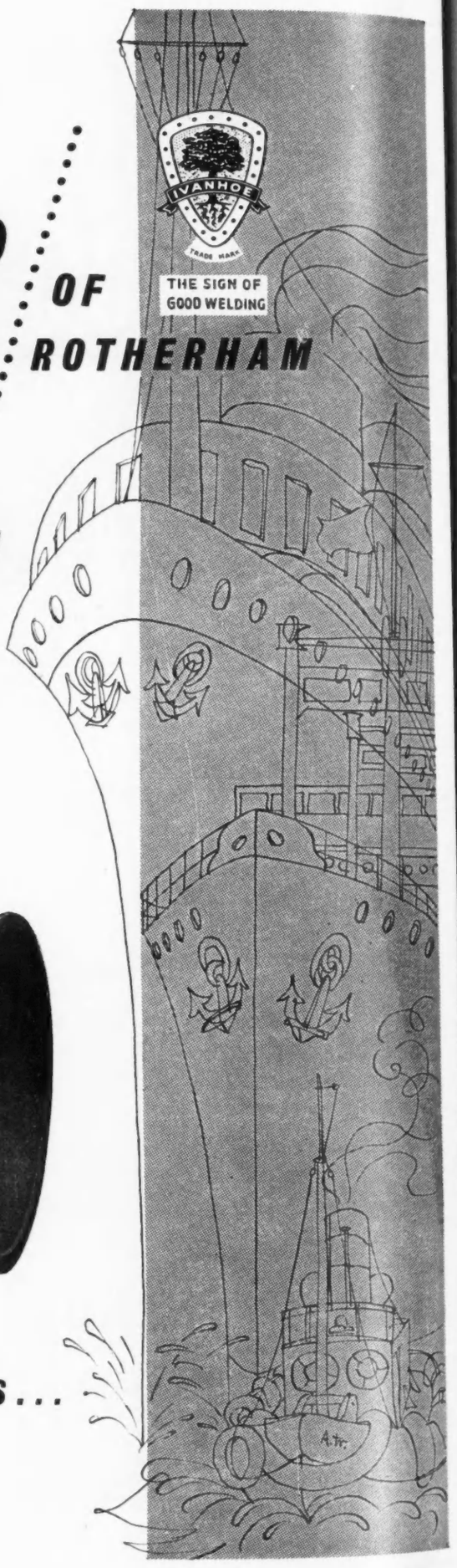
THE SIGN OF GOOD WELDING

SERVING THE SHIPPING INDUSTRY



Mild Steel Condenser Shell — 6′ 9″ inside diameter at ends x 15′ 6″ long, rectangular inlet, 4 supports built up from M.S. plate.



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for every industrial requirement

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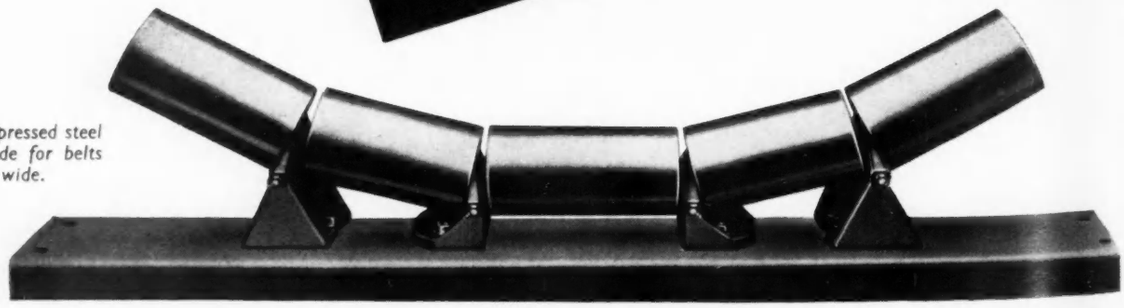
THE POWER PETROLEUM CO. LTD.

Head Office: 76/86 Strand, London, W.C.2.
(Branches & Depots throughout the Country)

Our Technical Department will be pleased to advise on your lubrication requirements and problems.

Five-pulley idlers carrying a 36-inch conveyor belt.



Idler rollers on pressed steel idler-board, made for belts up to 60 inches wide.

Because M&C idlers run so very easily, the belts they carry take less power to drive, belt life is increased and conveying costs are reduced. Double-labyrinth grease seals keep the ball bearings safe from grit and in perfect condition, in some cases for twenty years.

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The New "Six-Eight" Road-Marshall

The ROAD-MARSHALL Series "SIX-EIGHT" is a new medium weight Roller which has been produced in response to repeated enquiries from our customers. We know that many users of the heavier ROAD-MARSHALL Diesel Rollers wished to have a medium weight Marshall roller as well, but up to now this has not been available.

There are two sizes giving weights 6-9 tons and 7-10 tons. The usual wide range of extra equipment can be fitted to suit Customers' specifications.

Road-Marshall Tandems are available in three sizes 35-50 cwt.

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Road-Marshall Three-wheel from 6 tons

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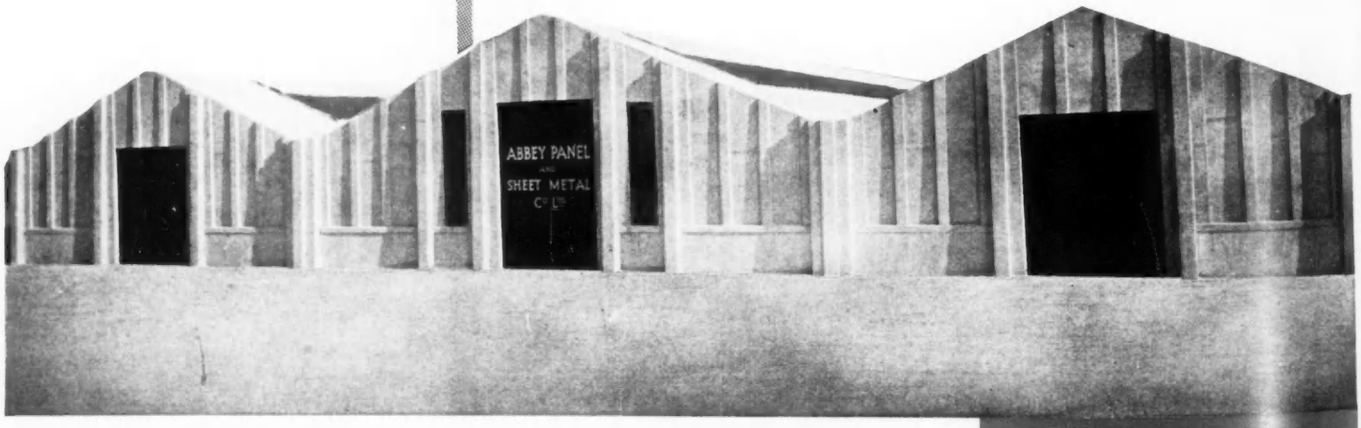
Current Beecham Achievements

"My Board are most impressed by the way you completed the existing factory within the stated time and I would add that we are highly delighted with the finished building.
It is very refreshing these days to get what you want, when you want it, without having to pay for a considerable amount of extras when you have got it. Your ability to execute this work so efficiently has helped us very considerably in meeting our own production commitments.
To meet additional requirements, I would appreciate it if you would quote me by return for extending the building by a further 20,000 sq. ft."

The extracts quoted are from a letter written by E. Loades, Esq., Managing Director of The Abbey Panel & Sheet Metal Co. Ltd., Coventry and Bedworth.

. . . completed to schedule this factory illustrates another successful Beecham contract, undertaken during a period of maximum production and against adverse weather conditions.

Concurrently Beecham Buildings have erected the largest prefabricated industrial building in this country ; a 200,000 sq. ft. factory in the Midlands. Their new ways of building allow Beecham to keep the pace on all their numerous contracts. For technical efficiency and well studied economy in Industrial Building you are advised to consult Beecham Buildings Limited.



BEECHAM BUILDINGS LIMITED

DEPARTMENT C

SHIPSTON-ON-STOUR, WARWICKSHIRE. Telephone: Shipston-on-Stour 315, 316 & 3287

Why not consult us on your industrial building programme? We shall be pleased to advise you.

Beecham Buildings

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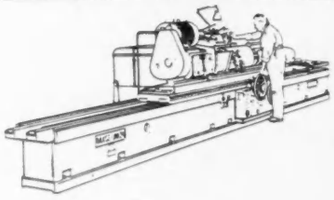
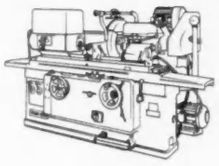
20 years double-shift duty and still working ✳

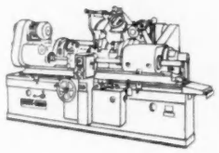
NAXOS UNION



Roll Grinding Machines 12 inches to 72 inches diameter.



Plain, production, and universal Grinding Machines.



Multi-wheel crankshaft, pin and journal, Plunge Grinding Machines.

Surface Grinding Machines. (Circular table).

Also
Surface Grinding Machines. (Reciprocating table).
Plano-type single or multi-head Slideway Grinders.

That is the record of this Naxos-Union Roll Grinder installed in the strip and sheet mill of one of Britain's largest producers, the equivalent of forty years continuous use, with only one interruption for a major part replacement.
Its standards of accuracy and finish are still unsurpassed by even its most modern counterpart; while for speed of operation and convenience it has no equal.
Although the operating company has a world-wide reputation for the quality of its products, and operates a ruthless re-equipment policy, this machine still remains as evidence of the inherent quality and fitness for purpose of Naxos-Union Roll Grinding Machines.

✳ ***THE SECRET***

Unique spindle construction ensuring that the wheel spindle runs on its theoretical centre regardless of side loading, is one of the main reasons explaining Naxos-Union accuracy. Add to this, precision micro-feed to the wheel head, and split-tenths accuracy follows. Mirror-finish too, of course, to 0.5 micro inches if you want it.

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MANAGING DIRECTOR DAVID C.Y. HIGGS, A.M.I.E.E.

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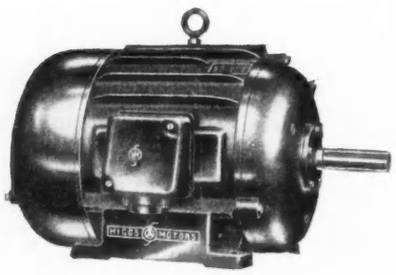

Standardised Motors to B.S. 2083/1954
Large stocks available for immediate delivery.

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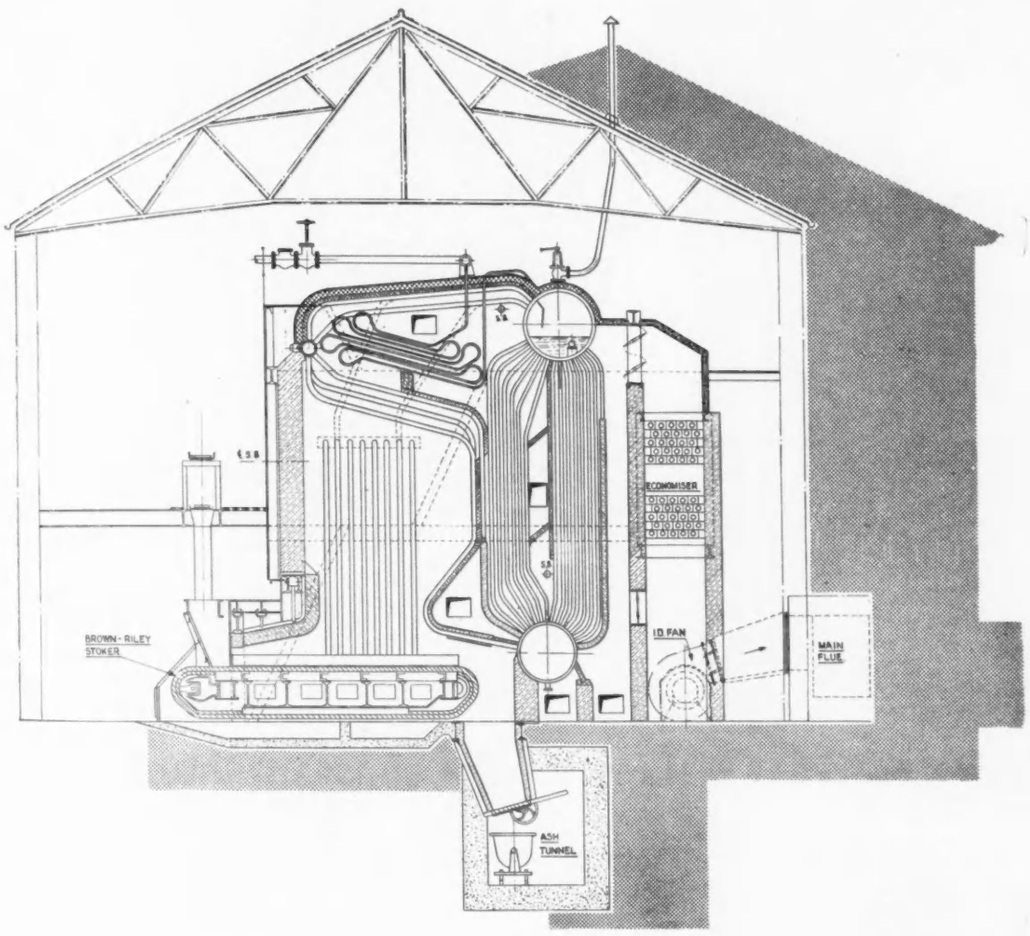
From the New Source



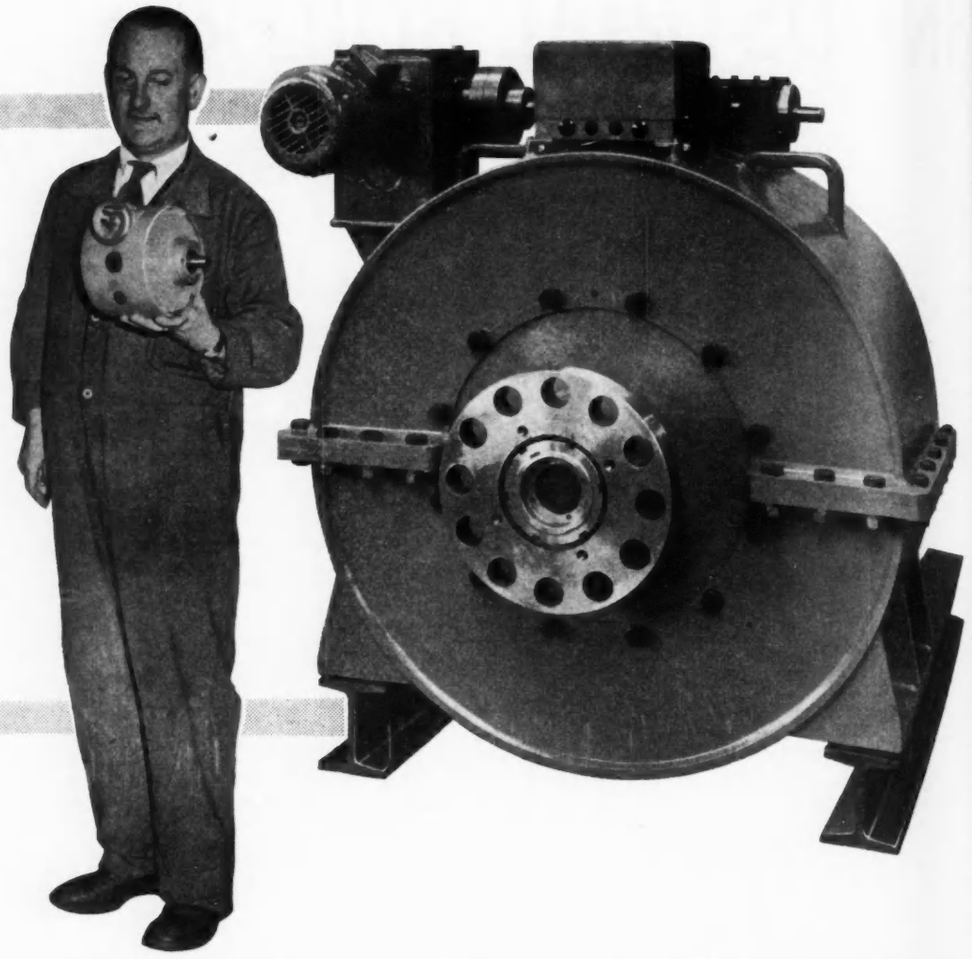
At Whitecrook Works, Clydebank, we build Industrial Boilers ranging in capacity from 14,000 lb./hr. to 150,000 lb./hr. Complete ranges of Mechanical Stoker or pulverised fuel firing equipment and all auxiliaries such as Economisers, Airheaters and Mechanical Draught Plants are supplied to suit individual requirements.

Typical of Industrial Boilers in this range is the installation now being built for the new generating station at Tzaneen Village in South Africa. With a capacity of 14,000 lb./hr. and complete with Mechanical Stoker, Economisers, Superheaters and Mechanical Draught Equipment.

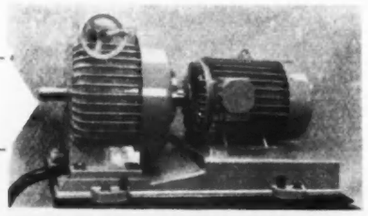
JOHN BROWN LAND BOILERS LTD

WHITECROOK CLYDEBANK GLASGOW

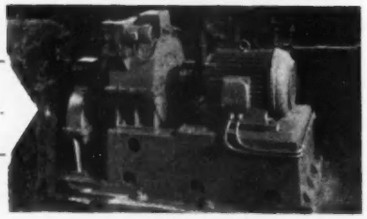
Infinitely Variable Gears



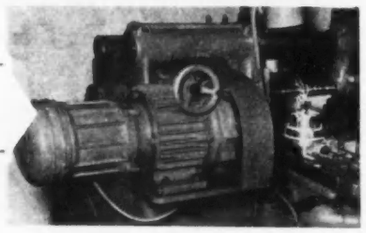
Available from 1/2 to 300 H.P.... with constant horse power!



MA 30 with Motor.



MA65driving roll lathe.



AS 3 with built-in reduction driving milling machine.

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- ***Compact.*** The Gearbox is a new conception based on proven principles, resulting in a remarkably compact and reliable unit.
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- ***Mechanical Efficiency.*** Very high at *all* speeds.
- ***Numerous Transmission Points*** contribute to the development of tremendous power.
- ***Oil Film.*** Design based on unique principle of torque transmission through the drag force in a thin film of oil between the driving and driven members, avoiding metal to metal contact.

BEIER INFINITELY VARIABLE GEARS

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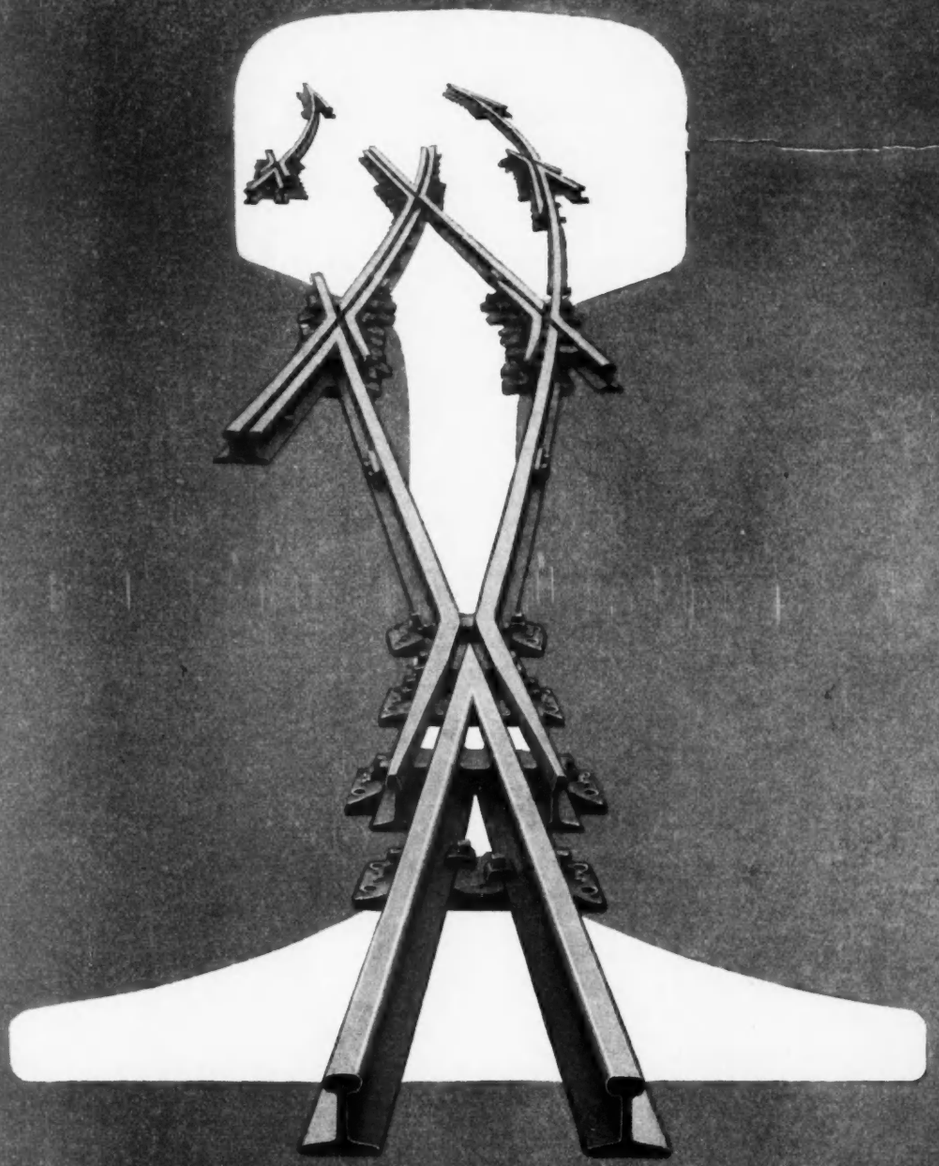
CLOSE, WORKS. GATESHEAD 8, CO. DURHAM • *IN ASSOCIATION WITH JARROW METAL INDUSTRIES LTD., WESTERN ROAD, JARROW.*

NEW 109 lb F.B. RAILS IN MANGANESE STEEL



For the first time in high Manganese Steel, the new 109 lb per yard F.B. rails have been rolled by Workington Iron & Steel Company and built by Edgar Allen & Co. Ltd., Trackwork Department, Sheffield, into the double junction illustrated. This has been supplied to the Southern Region, British Railways, for a location subject to very heavy traffic.

THE UNITED STEEL COMPANIES LTD

WORKINGTON IRON & STEEL COMPANY

WORKINGTON Phone: Workington 206. Grams: "Mosbay" Workington CUMBERLAND

Branch of The United Steel Companies Limited

W 104

large and complex

or small and simple

Our business is solving casting problems. This engine crankcase casting, for example, that we are supplying for the Napier *Nomad* presented several ; it is four feet high and of quite intricate design. Nevertheless, those castings at the other end of the scale, the small and simple, receive at our hands the same care and attention. That being so, as numerous manufacturers have found, you cannot do better than to entrust casting operations to us.

J. STONE
& CO (CHARLTON) LTD

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SAND, DIE AND PRECISION CASTINGS IN ALUMINIUM, MAGNESIUM AND BRONZE

Meet Perishin' Fred!

Very fond of a grouse is Fred. Doesn't have to look far either. 'Like the perishin' North Pole in this perishin' factory', growls Fred. But at least he stays on the job; half the girls are away with the sniffles.

Now meet Bert — of the boiler'ouse

'It's no good them coming grousing to me,' glowers Bert, 'radiators are full on (or nearly), and the Guvnor's always bitin' my 'ead off about the fuel bills.'

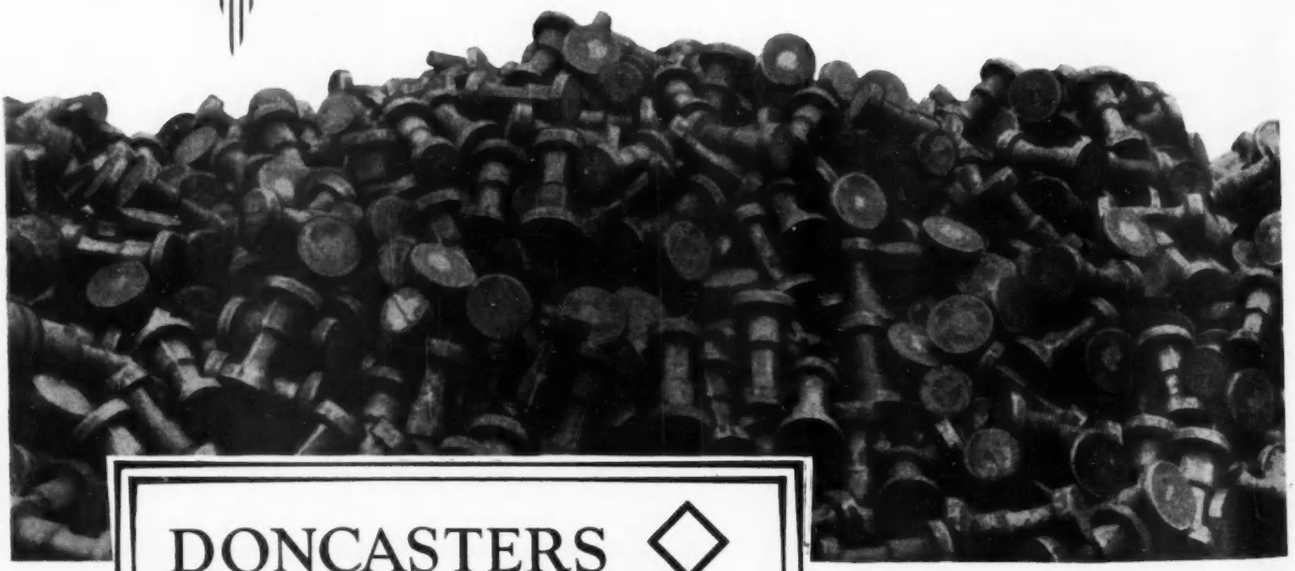
You know the answer to all their troubles as well as we do. Inter-line that corrugated roof with inexpensive, easily-applied, everlasting Fibreglass heat insulation. Then Fred will stop perishin', Bert will stop beefing and the 'Guvnor' will stop biting. What's more, the installation of Fibreglass *will pay for itself* in less than three years!

wrap that factory in **FIBREGLASS** TRADE MARK

FIBREGLASS LIMITED, RAVENHEAD, ST. HELENS, LANCS. (ST. HELENS 4224). FACTORIES AT ST. HELENS, LANCS. AND POSSILPARK, GLASGOW

DONCASTERS

for
Drop Forgings
in large
or small
quantities



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DANIEL DONCASTER & SONS LIMITED · SHEFFIELD

FORGINGS · DROP FORGINGS · HARDENED STEEL ROLLS · HEAT TREATMENT

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SCHIESS

VERTICAL CYLINDER BORING MILLS

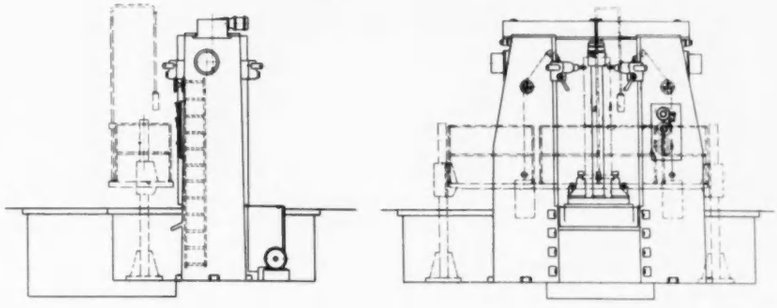
efficient
economical
accurate
space-saving

Model KZ

for rough and finish-boring of cylinders, with fixed boring bar and rotating cylinder, and for the machining of the outside of the cylinders by means of the side head. Also suitable for normal turning work.

Model BZS

for rough and finish-boring of cylinders with rotating boring bar and stationary workpiece. Single-purpose machines for internal machining only.



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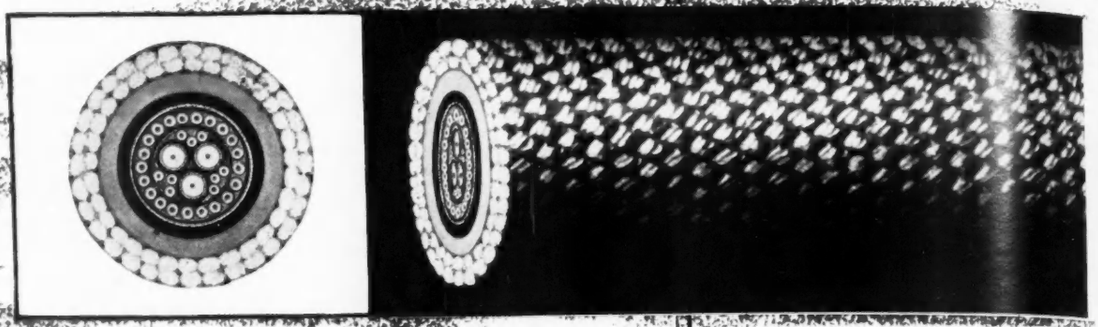
Agents United Kingdom and Eire, **BURTON, GRIFFITHS & CO. LTD. BIRMINGHAM**



This cable carries weight

BICC Combined Camera Cable and Lifting Rope for underwater use.

This special multicore T/V camera cable is also used as a rope. It contains all the necessary electrical circuits and supports the full weight of the underwater T/V Camera by means of an overall hemp loom braid. It was designed and manufactured by BICC to meet the requirements of Messrs. Pye Ltd.

During recent trials the camera was repeatedly lowered and operated by this cable. Depths of 83 fathoms were reached and clear pictures obtained. Throughout the trials the cable was subjected to many severe tests. ★ ALL CIRCUITS REMAINED INTACT.

BICC ARE ALWAYS PREPARED TO DESIGN AND MANUFACTURE CABLES TO MEET SPECIAL REQUIREMENTS.

★ *It withstood a 2½ cwt. shock drop of 20ft. out of water; towed the camera at speeds up to 12 knots; raised and lowered the camera at 250ft. per minute over narrow diameter pulleys and capstan.*

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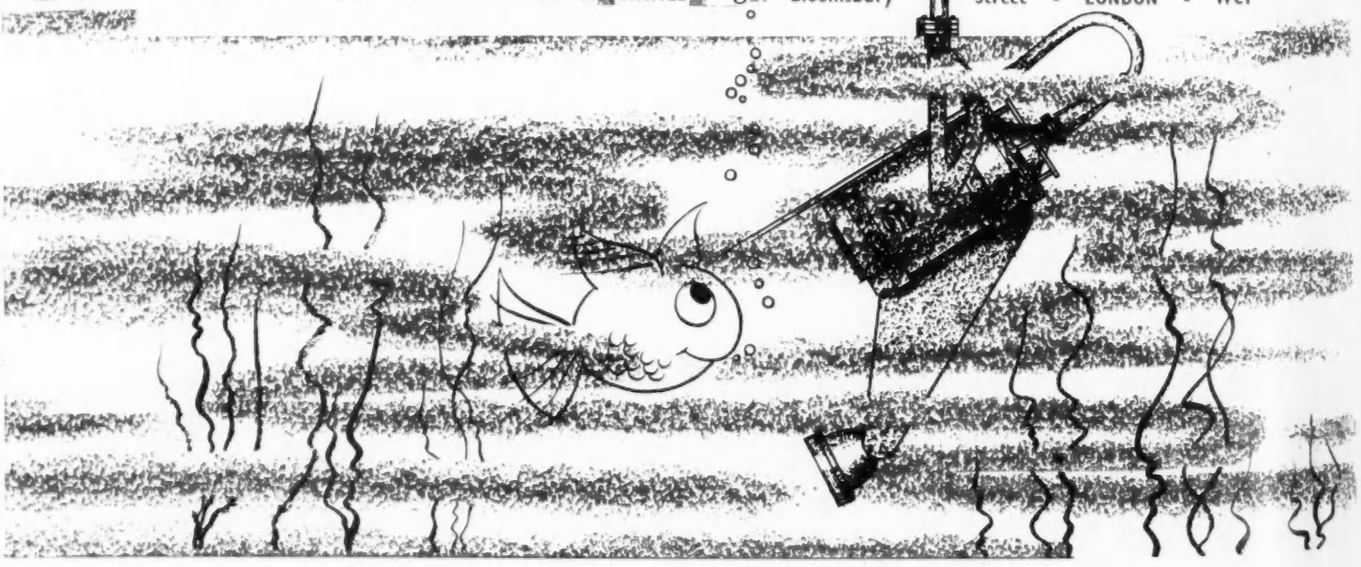
BICC T/V CAMERA CABLES

BRITISH INSULATED CALLENDER'S CABLES LIMITED - 21 Bloomsbury Street - LONDON - WC1



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Faster and better by

Plessey

LIGHT & HEAVY DUTY CRIMPING EQUIPMENT

No other electrical tag-to-lead connection is so quickly accomplished, so long lasting, so thoroughly reliable as that which is made by a Plessey crimping tool. These precision crimping tools range from a hand-operated light duty type, through to a heavy duty hydraulically-operated unit. Originally pioneered and developed for the aircraft industry to overcome the disadvantages of corrosion, crystallisation and other accelerated deterioration factors in any method employing heat and flux—this solderless crimping method achieves a wiring connection which is both mechanically and electrically superior for a fraction of the cost.

For its success, any crimping process relies wholly upon the accuracy of the equipment used. Consistent with such standards these advanced tools are produced to fine engineering limits from the finest materials.

Plessey publication 753/1 contains extensive details of these tools and their application. A copy will be sent to manufacturers free, on request.

THE PLESSEY COMPANY LIMITED • ILFORD • ESSEX

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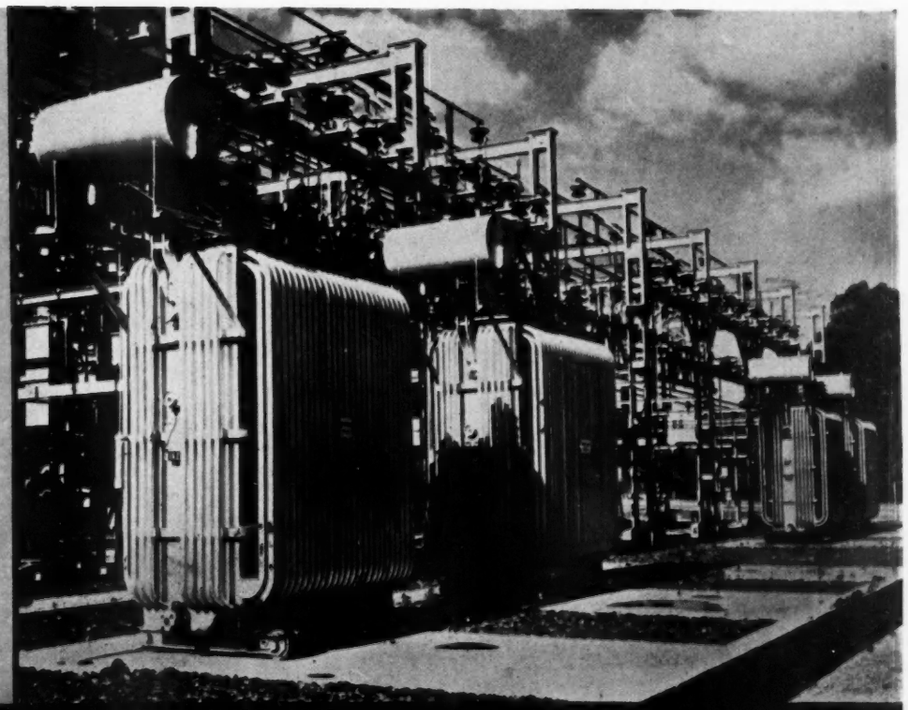
POWER TRANSFORMERS

2000 kVA
33 kV/11910-3420 volts
3 phase transformers
at the Oakdale
Distribution Station of
Cape Town Electricity Supply Commission

Full range of types in capacities from 5000 kVA at 33 kV and to 10000 kVA at 66 kV.



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THE ELECTRIC CONSTRUCTION COMPANY LTD.

Head Office and Works:
BUSHBURY ENGINEERING WORKS
WOLVERHAMPTON
ENGLAND

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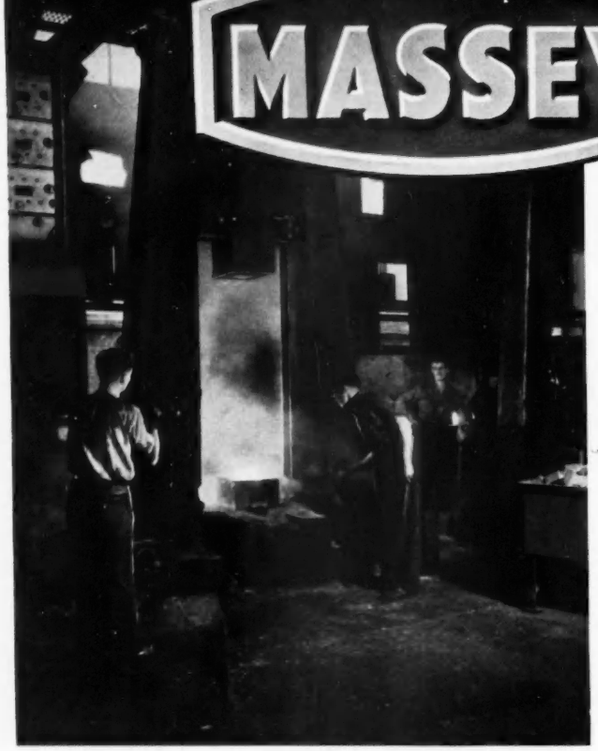
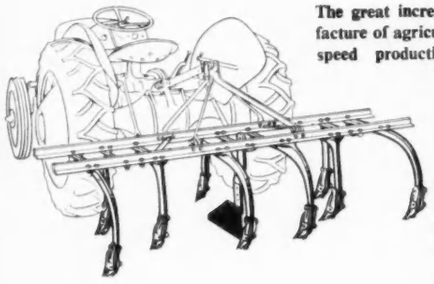
Manufacturers of Rotating Electrical Machinery, Switch and Control Gear, Rectifiers and Transformers.



MASSEY FOR FASTER FORGING

FOR AGRICULTURAL MACHINERY



The great increase in the mechanisation of manufacture of agricultural machinery has demanded high speed production of forging components, and MASSEY Forging and Drop Forging Plant is used extensively in this field of engineering industry. The photograph shows a Massey Friction Drop Hammer installed at Garringtons Ltd., Darlaston, and is one of many used for forging parts for the famous Ferguson Tractor.

Full details of Massey Forging and Drop Forging Plant will be forwarded upon request.

Massey designs include:
Steam and Compressed Air Hammers, Pneumatic Power Hammers, Spring Power Hammers, Friction Drop Hammers, Double-acting Steam and Compressed Air Drop Hammers, Forging Presses, Trimming Presses, Tyre Fixing Rolls.

Photograph by courtesy of Messrs. Garringtons Ltd., Bromsgrove.

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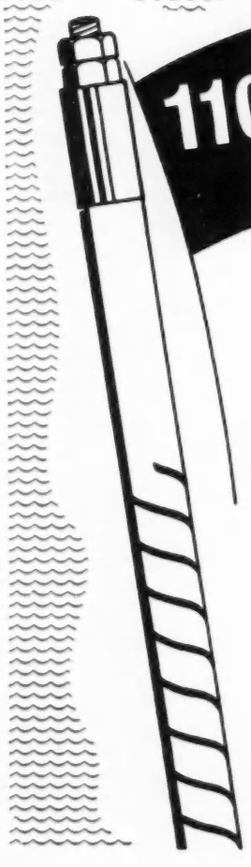

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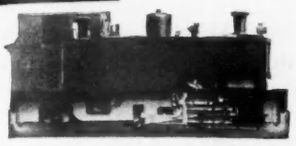

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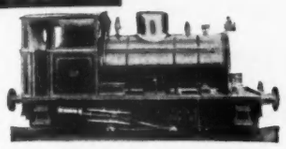

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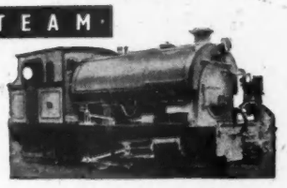

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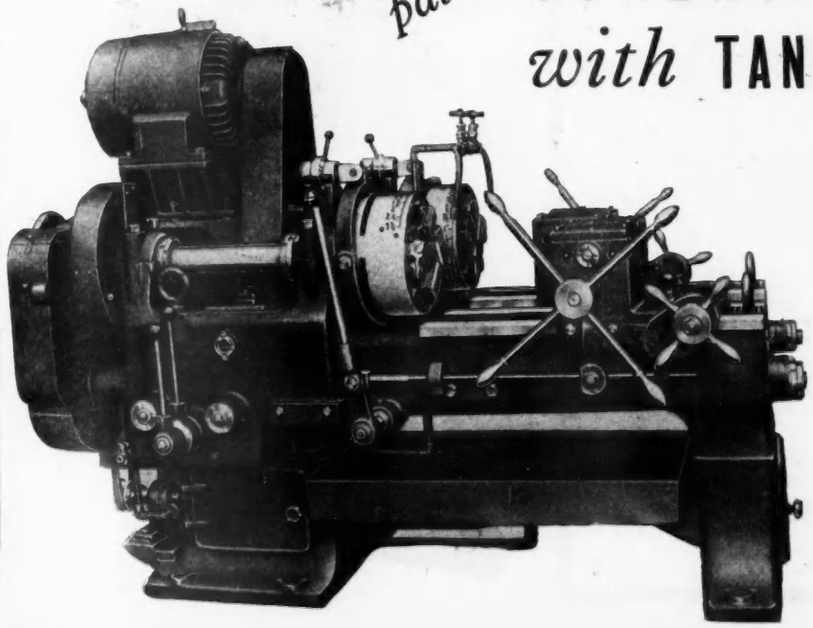

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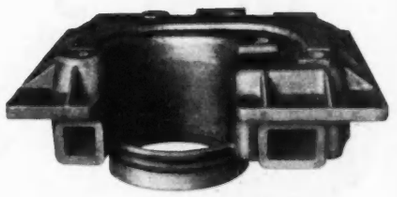

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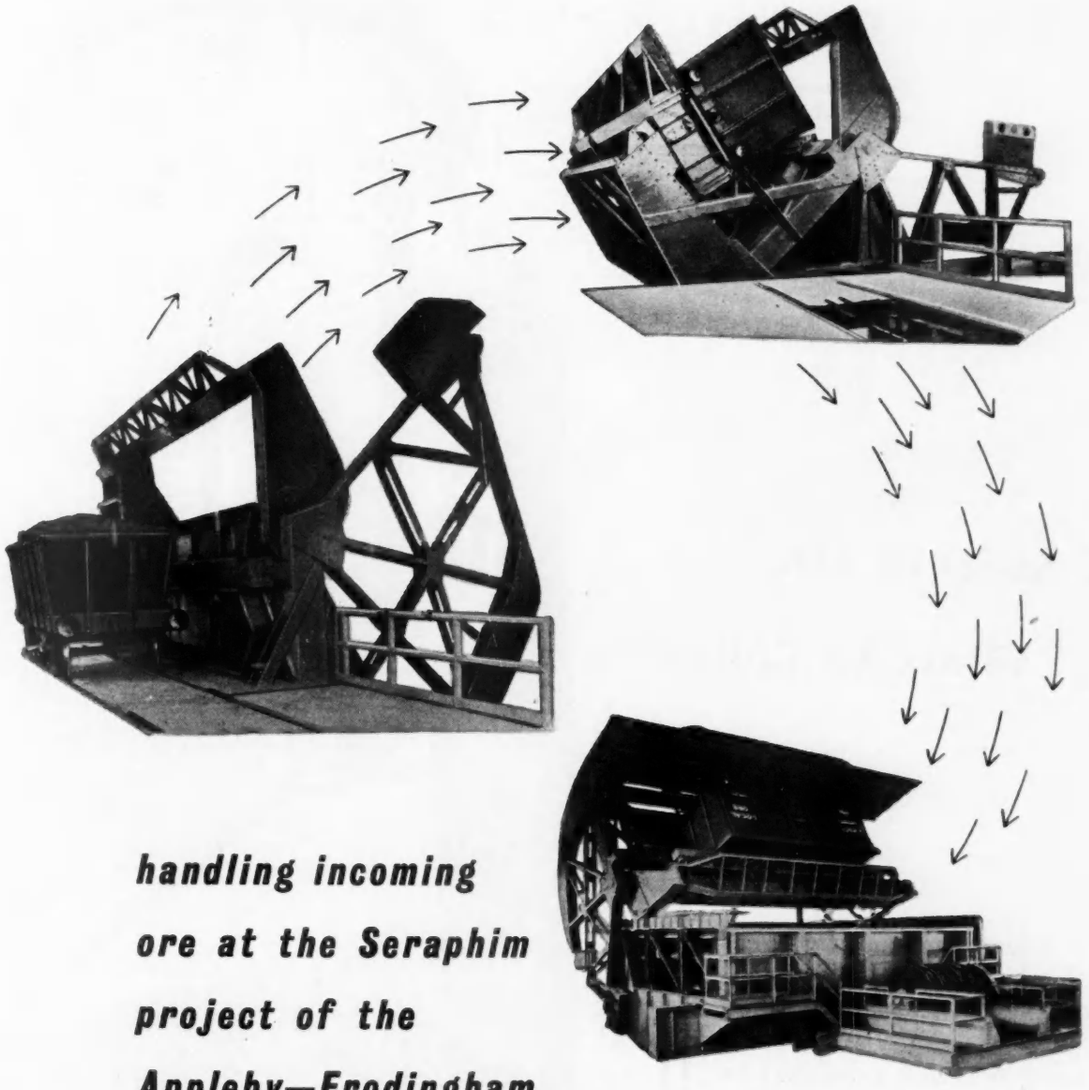

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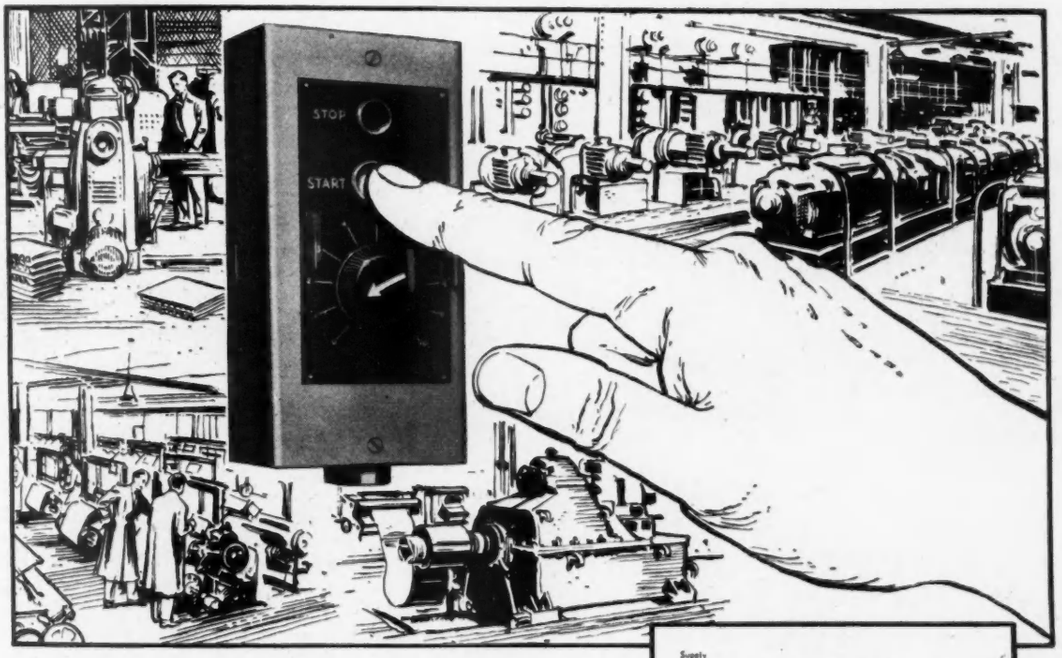

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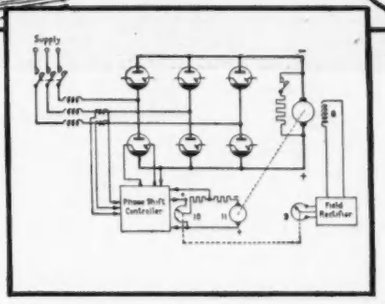

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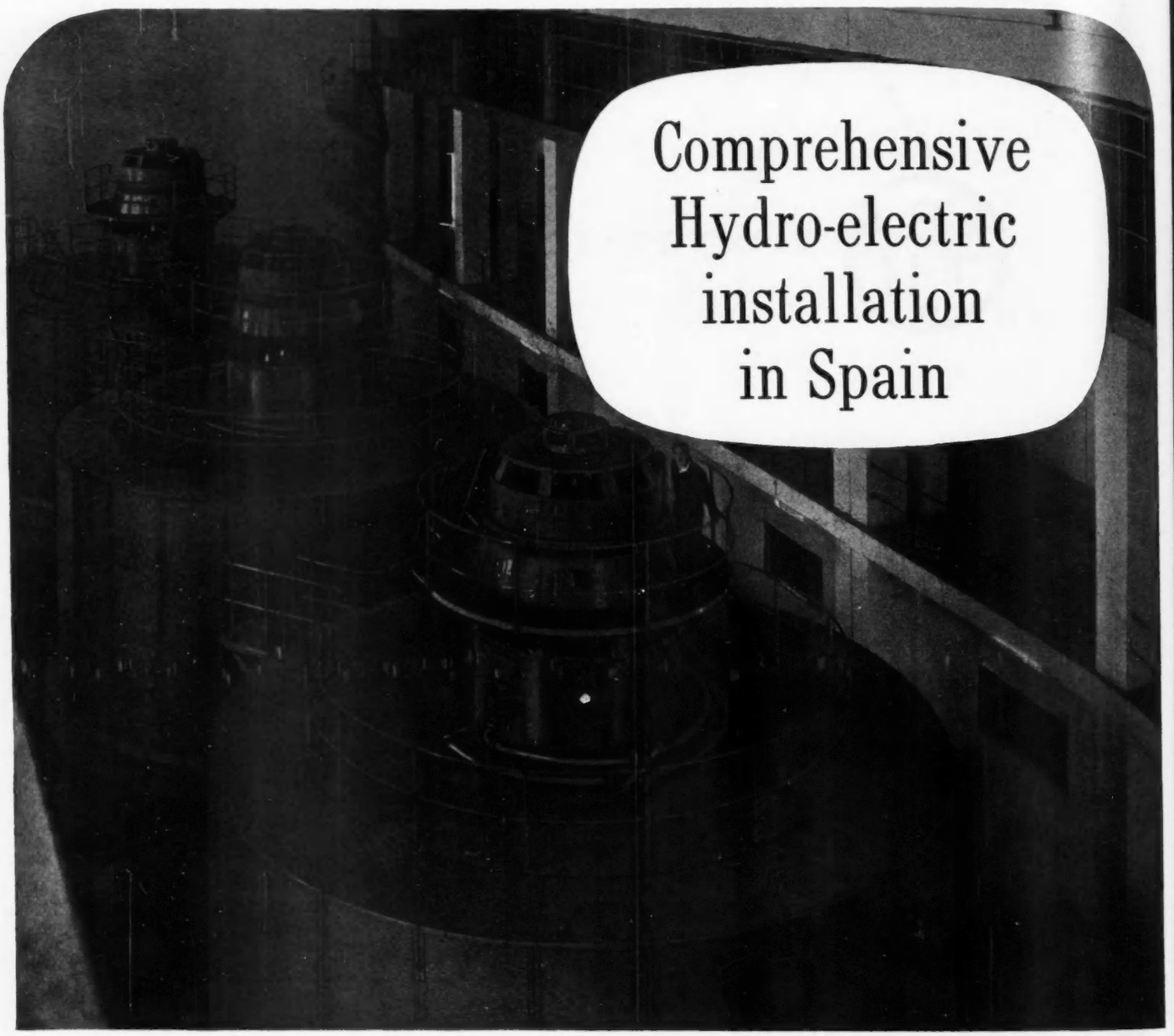

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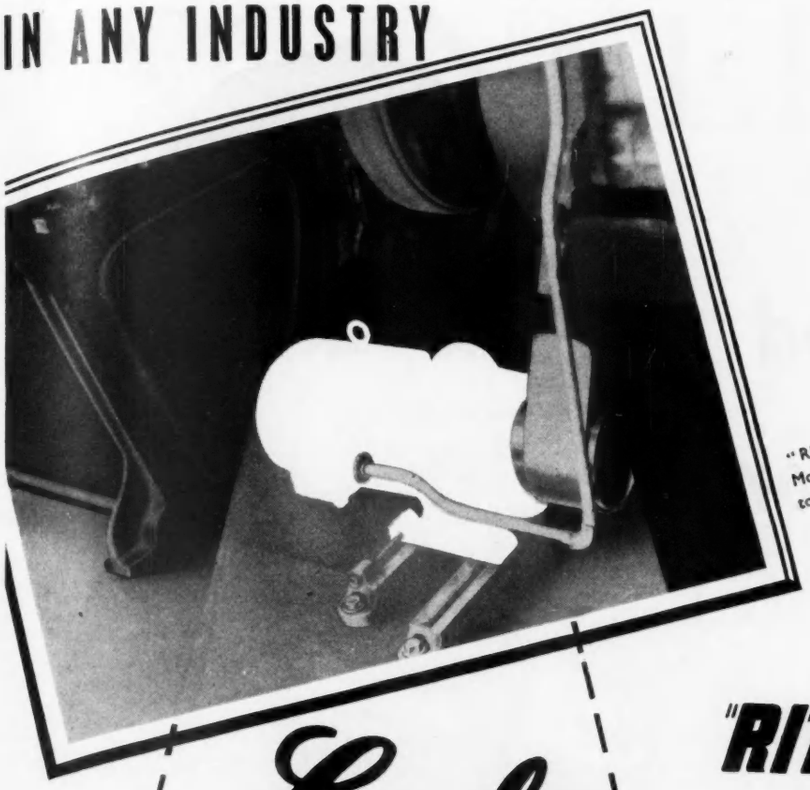

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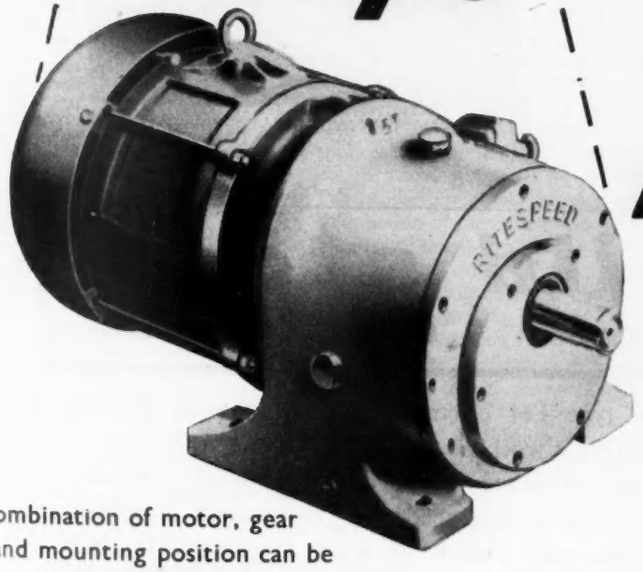

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ENGINEERING

An Illustrated Weekly Journal

Vol. 181 No. 4695 JANUARY 20, 1956

Leading Article

"A Vacancy Exists . . ." 65

Weekly Survey

Staff College for Under-developed Areas 66
Hawker's Spread their Risks 66
Future Electric Motive Power 66
Heavy Electrical Successes 66
Efficient Small Firms 67
Trial of Strength 67
Virtue or Necessity? 67
Car Rumours on Clydeside 67
Institution Membership for Eminent Engineers 67

Principal Articles

No. 4 Blast Furnace at Margam 68
Attracting New Recruits: Foundry Industry's Challenging Task 69
Electronic Computers for Structural Analysis: Five Problems Resolved 69
The Louis Breguet Memorial Trophy: For Decreasing Speed at Take-off and Landing 69
The Man Engine: Early Mechanical Method of Raising and Lowering Miners 71
The Engineering Outlook—2: Manpower in Engineering: Wages Chasing Productivity 76
Water-Cooled Reactors: Designing Power Plants to use By-Product Plutonium 78
Approval and Dissent (Discussion on Water-Cooled Reactors) 82
Stresses in Boiler Tubes: Routine Procedure Suitable for Desk Calculating Machine 84
Performance of the Seamew 87
Small High-Speed Copy-Turning Lathe: Free-hand Turning as Alternative 88
Correcting the Power Factor: Installation of 12 MVAr Capacity 89
Large Precision Milling Cutters: 6 in. Depth of Cut 90
Processes, Quality Control and Cutting Research: Speeding Aircraft Production 91
Metal Cutting Operations 93
Checking Surface Finish: Measuring Roughness with a Portable Instrument 94

Obituary

Sir Felix J. C. Pole 72
Mr. A. L. Mellor 72
Dr. F. Sherwood Taylor 72

Book Reviews

Principles of Helicopter Engineering 74
Swiss Type Automatics 74
Noise 75
Law and the Engineer 75

Notes

Radio Trades Examination Board 69
Dynamic Characteristics 72
C.I.G.R.E. 1956 87
Engine Test Tunnel for Lufthansa 87
Soft-Soldering Aluminium Alloys 87
Grouped Engineering Workshops at Stocksbridge 88

The Human Element 96

Personal 70, Commercial 70, Contracts 70, Books Received 73, Trade Publications 77, Notices of Meetings 95

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"A VACANCY EXISTS . . ."

It is a common experience to-day to have to choose between two or more jobs that are offered. The time when a firm could advertise a vacancy and expect to receive many replies seems to have gone, never to return. The employee is faced with a dilemma, the employer with a problem. For both, the ingredients of the situation on which the final decision is taken are difficult to define. The salary or wage, assuming it to be adequate, may be relatively unimportant compared with the host of other factors which the prospective employee will ponder.

The biggest single factor is undoubtedly the degree of opportunity which the post carries. Different applicants have different ideas as to what constitutes opportunity. Some will inquire into the salary prospects, but most are likely to consider the scope for gaining professional experience and perhaps a professional reputation, especially as it is broadly true that the higher the rung on the professional ladder the higher the salary. It is not always easy for a firm to convey a clear picture of the prospects, since future plans may hinge on a number of unknowns. But unless an attempt is made to impart a sense of tangible, even exciting, prospects the chances of recruiting the best man are remote. What kind of work is waiting to be done? How much responsibiiity will the applicant be given? Is the business expanding, or does it appear to be stationary? The prospective employee may have only a hazy notion of the nature and quality of the firm, based largely on what he knows of their products and what he has seen in their publicity and advertising matter. In any correspondence with him, and particularly during the interview, it is vital to impart such an impression that he will want to join the firm even though his previous knowledge of it was almost negligible.

The nature of the job is, of course, a fundamental factor; whether, for example, it is management, research, production, design, sales or some other function. If current advertisements in the technical Press are a reliable guide to the aspirations of engineers to-day, no one wants a job that is highly specialised. Like the movement to bring diversity of industry to the former depressed areas of the kingdom, the wide-awake employer dangles the bait of varied experience. As bait it may have superficial value, but an applicant would be remarkably short-sighted if he did not recall that many a specialist has carved out a highly rewarding niche for himself, and that the greatest achievements are usually the work of those who can bring a natural breadth of vision to bear on a narrow field of endeavour. More important, perhaps, is the question whether the work is primarily the continuance of existing practices and organisation, or whether it is the task of creating something new. One is not necessarily more enjoyable than the other, but each needs interpreting to the applicant in a different way. So, too, does the big-fish-in-a-small-pond or the small-fish-in-a-big-pond circumstance. Related to these factors is the scale of equipment and staff with which the prospective employee will be able to work. One man may expect everything to be there for him to take over, but another may relish the prospect of building up the organisation.

Here we touch on a crucial factor. An expanding industry should have no difficulty in recruiting men. "Opportunity" is written all over it. If, in addition, its products or service are recent innovations with a popular appeal, it is likely to be in the happy position of being able to choose from a large number of applicants. But almost every industry operates under some disability. A nationalised industry, for example, though it can offer security (a quality which still, in spite of full employment, has its attractions), cannot offer that sense of personal relationship and scope that is to be found in a healthy company. The National Coal Board and the British Transport Commission—to take only two—might do much more to "sell" their industries. They ought to attach more importance to this aspect of their relations with the public, if only because they suffer from adverse publicity of a kind which few companies have to contend with. In the case of the railways there is still a fund of public interest and goodwill which could be fostered so as to counteract the baleful limelight which accidents, debates in Parliament, and letters and articles in the Press focus on British Railways. In the case of the Coal Board, the enormous capital investment programme carried out since the war, and still continuing, provides innumerable opportunities for telling engineers, future engineers and the public generally that coal mining is a progressive industry. These opportunities have not been firmly grasped.

Pension funds, free or subsidised meals, the opportunity to travel, help in finding a house—all these and similar considerations are important, but they are only the first step. Something less tangible but more significant lies beyond them. The applicant must feel that he, and he alone, is wanted, and that in his new environment he will be able to do something far, far better than he has ever done before. As Lord Woolton has said, a good organisation allows common men to do uncommon things. They can do that only if there is the utmost confidence between them and their employers. And confidence does not grow by accident.

Weekly Survey

Cover Picture: *If it were not for the caption "The Village Smithy", it would be reasonable to assume that the photograph was taken in some corner of an engineering works. But the ubiquitous oxy-acetylene torch is as much the tool of the blacksmith who serves the farmer as the cutter and welder in engineering.*

★ ★ ★

Staff College for Under-Developed Areas

It has been known for some time that the World Bank was planning an Economic Development Institute where senior officials from the less developed countries could be given a "staff" course on economic problems. The Institute was formally opened in the U.S.A. on January 10. Its director is Professor A. K. Cairncross, Professor of Applied Economics at Glasgow University. Each course will last six months and the first one is being attended by 14 officials. The cost of the scheme is being shared to begin with by the World Bank, the governments concerned and the Ford and Rockefeller Foundations.

An Institute of this kind must perforce prove its usefulness as it goes along. There is clearly a case for an organisation of this kind, for much of the hope for success in developing backward territories lies in bringing local officials into contact with the best of current thought on economic and technical matters, and showing them how their acquired expertise (most of them being trained Government officials of proved but somewhat stereotyped ability) can be dove-tailed into modern and progressive techniques. The World Bank has certain advantages in sponsoring this new idea. It has accumulated a good deal of first-hand experience in investigating development projects throughout the world and financing them over the last ten years or so. This body of experience should prove valuable in helping to keep the courses with their feet firmly on the ground.

In his opening address, Professor Cairncross said that it was a matter of practical urgency to raise the standards of living in many countries and that it was also urgent to find some alternative to violent and dictatorial methods of economic advance, so conveying to relatively backward peoples a sense of movement, purpose and participation. He thought that the intellectural problems posed by the widely varying rates at which development occurs, in different countries at different times, was even more challenging. He said that the Institute's task was to enhance the potential usefulness to their countries of a picked group of administrators whose normal duties had some fairly direct bearing on economic development. The main effort would be centred on making economic problems more intelligible and on sifting the various expedients by which they have been handled so as to find out which were successful and which were not. In carrying out this task the Institute would have full academic freedom.

★ ★ ★

Hawker's Spread Their Risks

Sir Thomas Sopwith's remark to shareholders at the annual meeting of the Hawker-Siddeley Group Limited last week on the need for industry to make large profits received a good deal of publicity. Certainly group trading profits before taxation have jumped in the year ended July 31, from £6,976,354 in 1954 to £11,675,537 in 1955. Said Sir Thomas, "Our profits are a reflection of excellent workmanship and efficient management, and they represent only a moderate return on the greatly increased turnover of our operating companies in their varied activities both at home and abroad." But the need for large profits is not only to increase competitive power in world markets (a point emphasised by Sir Thomas) but also to provide capital to acquire new interests. Hawker are already carrying out a policy of diversification.

The tenth anniversary of A. V. Roe (Canada), Limited was celebrated with the acquisition of the Canadian Car and Foundry Company, Limited. An important aspect of this acquisition is the greater breadth of industrial interest brought to the group, emphasising Hawkers' determination to expand non-aviation activities as less emphasis is placed on the country's need for conventional defence equipment. Further examples of Hawker-Siddeley diversification are evinced by the fact that Armstrong—Siddeley's output of Diesel engines expanded by 35 per cent. over the year, while 60 per cent. of total ouput was exported. Facilities are being extended to increase production of Diesel engines still further, while output of High-Duty Alloys has been aided by substantial overseas orders, particularly from New Zealand. Extensive contracts have been secured for housing projects in Australia by Hawksely S.M.D. Limited. In Canada, A. V. Roe are producing a wide range of products, including gas turbines, railway equipment, buses, mining equipment, steel castings and light-alloy products. Meanwhile, 1955 saw the formation of the Hawker-Siddeley Nuclear Power Company Limited, and negotiations are proceeding which will establish a nuclear research station for the group. In anticipation of the large sums of money which must be spent on development both in this field and in the important applications of electronics, relatively high profit margins are essential.

Military aircraft and equipment, however, continue to be the main field of the Hawker-Siddeley Group. In the year under review, three new variants of the Gloster Javelin were announced, and the two-seater Hunter is attracting considerable interest from all over the world. In the important field of guided missiles, substantial Government contracts should fully justify the erection during 1955 of new workshops and laboratories, and the purchase of up-to-date equipment and tools. For the immediate future, Hawker-Siddeley have no fears about finding markets for their aircraft. "The first deliveries of the Hawker Hunter to Sweden have begun, deliveries to Denmark will soon commence and a contract has been signed with the Peruvian Government for deliveries to begin this spring." In the more distant future, Sir Thomas is confidant that gathering of other interests the group will continue to prosper.

★ ★ ★

Future Electric Motive Power

There have been signs recently that the attitude of the British Transport Commission towards alternating-current traction at the industrial frequency is much less lukewarm than at the time of the 1951 report on electrification of railways. While awaiting a statement of policy, it is of interest to consider the events of the past four years which have justified a new outlook on the subject.

Pre-eminent among them are unquestionably the achievements of the French National Railways and their collaborators in French and Swiss industry, not only in carrying out so large a project as the Lille-Thionville electrification, but in investigating alternative methods of using industrial frequency for traction and pointing the way towards the most useful. The proposed equipment of future 25kV schemes, such as those from Paris to Lille and Strasbourg to Basle, will include a higher proportion of rectifier locomotives than were allotted to Lille-Thionville, and in direct-current countries which may eventually go alternating current to a greater or less extent, it is generally agreed that the compromise of collecting an alternating supply, but using direct-current traction motors, is likely to be the most satisfactory solution. There is, in fact, an advantage over the conventional direct-current locomotive in that in the rectifier design the motors are permanently in parallel, and therefore a tendency to wheel spin when starting heavy loads does not lead to racing of the motors on the unloaded axles, with reduction of tractive effort from the others, to the same extent as with the series connection. Already the development of commercial semi-conductor power rectifiers holds out to the designers of rectifier locomotives the promise of sturdy units which can be assembled in various ways according to the shape and size of the space within which the unit to be accommodated. Meanwhile French has interest in 50 cycle series motors continues the *solution sportive* to the 50 cycle problem as it has been termed, because it tackles the fundamental difficulty of poor commutation instead of by-passing it. A future for these motors is predicted in motor coach stock, which accelerates rapidly through the zone of difficult commutation to speeds at which the normal correction by interpole shunts becomes effective. At first the heavy currents taken by 50 cycle motors made forced ventilation essential, but to-day motor coaches are being supplied by French builders to the Turkish State Railways with self-ventilated motors and natural draught cooling of the transformer oil. Apart from saving space and weight, simplifications of this sort will be welcomed by all concerned with maintenance. There is no doubt that for those nurtured in direct-current practice the prospect of having to cope with transformer cooling-oil pumps, additional blowers, motor-operated tap changers and so on robs the much-sung advantages of the 50 cycle system of some of their attractiveness.

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Heavy Electrical Successes

With five more world records to the Canberra's credit during 1955, the English Electric Company, Limited, can be justifiably proud of their achievement in the aircraft industry over the past few years. The reputation of the Canberra, substantiated last year by orders from Ecuador, Peru and France, was an obvious stimulant to the introduction of a new version in 1955. The Canberra Mark 9 high-altitude photographic reconnaisance aircraft made its first flight last year and flight development is well under way. Meanwhile, quantity production of previous marks of the Canberra continues.

The review of the activities of English Electric which is introduced by this record of aircraft success is a comprehensive and stimulating report on the wide range of activities of the group in 1955. One of the most important developments in the year under review was the announcement by the British Transport Commission of the railway modernisation plan with a consequent placing of the first orders later in 1955. English Electric, while securing a substantial proportion of these orders, have not neglected the overseas market for locomotives. Of interest from the important viewpoint of dollar markets, however, were substantial contracts received for the supply of transformers for projects such as the St. Lawrence Seaway, the Table Rock Dam and the Wilson Dam. Chief Joseph was also in the news early in 1955, and in Canada, English Electric's associated company, John Inglis Company, Limited, of Canada, secured the order for all 16 turbines on the Canadian side of the St. Lawrence Seaway project. A new range of protected-type industrial motors have been particularly well received in the dollar market, as they are interchangeable with American standard types.

Atomic energy has been much in the news lately and the General Electric Company, Limited, were one of the four companies invited by the Government towards the end of 1954 to undertake design study of the gas-cooled graphite-moderated thermal reactor. Extensive laboratories have been built since this announcement and research work has been undertaken by G.E.C. into the reactor properties of several constructional materials, fuel elements, moderators and coolants. A review of atomic development at G.E.C. is included in the report issued by the group on their activities for the past year.

Elsewhere, the Lisbon Metropolitano, the

first underground railway to be constructed in Portugal, is being equipped almost entirely with G.E.C. electric lifting and ventilation systems. In the field of road transport, a significant point is the revived orders for trolleybuses which until quite recently were regarded as out of favour by London Transport. Probably stimulated by the possibility of cheaper electricity from atomic energy in the future, 30 new trolleybuses and the accompanying equipment are being installed by Glasgow Corporation, for which G.E.C. have received the contract for traction equipment. Meanwhile, a high proportion of traction equipment for Diesel-electric locomotives going abroad continues to form a major part of this type of production. Although the Sterling Area continues to remain the chief source of export orders, sales to the Dollar Area have increased and, to judge from recent contracts and a far-sighted selling policy by the major companies, they should expand still further.

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Efficient Small Firms

"To help to persuade the smaller firm that production control, far from being a management function which they cannot afford, is one that they cannot afford to be without," is the aim of a report that has been issued by a joint committee of the Institute of Cost and Works Accountants and the Institution of Production Engineers. The report, entitled "Production Control and Related Works Statistics," is based on the answers to a questionnaire given by 229 firms in 14 different industries. Of these firms, 73 had less than 500 employees, which would seem to imply that the majority of the information relates to firms which definitely fall into the "medium" or "large" category. Engineering showed the widest range in size, for the 121 firms concerned ranged from 21,800 employees down to 40. The number with less than 500 was 37, and the same ratio of large to small roughly maintained throughout the 14 industries examined.

At a meeting held last week for the purpose of introducing the report, Mr. L. W. Robson, joint chairman of the committee and a representative of the Institution of Production Engineers, said that they had not found any general standard for measuring productivity, though good production could always be recognised.

The degree of production control employed must always depend on the particular application. Statistics can be multiplied beyond useful and reasonable bounds, leading to much unnecessary expense. Equally, too few facts can also lead to expense by wastage of time and materials, or missed opportunity. Comparatively few facts are needed to maintain a good organisation, but the intelligent use of them is vital. These are the points brought out in the report, together with suggested methods for using them in the various operations of medium and small firms. Details of the report, which has the approval of the British Productivity Council, are given in our "Books Received" column.

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Trial of Strength

Last week the Standard Motor Company, Limited, turned down a demand from 11,000 workers for a big increase in wages. The incident is of particular interest at the moment to the engineering industry for a number of reasons. At present the A.E.U.'s demands for a 15 per cent. increase in wages is under negotiation and any bargaining position taken up by a large concern in the industry must obviously affect the climate of negotiation for the industry-wide wage claim. This situation is true even though Standard is a non-federated company and like other motor manufacturers pay particularly good rates. A further complication has arisen with the announcement only four days before that the British Motor Corporation Limited and Rootes Motors Limited have put some of their workers temporarily on a shorter working week. The Standard Motor Company have put great stress on the increasing problems of selling cars abroad and the need to pass on any economies to the customer rather than let them go in higher wages. It will, of course, never be known how far this is a genuine argument based on current conditions in the motor-car industry (it could certainly be considered as such) and how far the short time at Austins and Rootes is a heaven-sent bargaining point for the company.

There is no doubt that the claim is a unique example of the problems which may soon face the whole engineering industry if the employers' assertions that business, especially in export markets, is likely to get more difficult, are proved to be correct. This case at Coventry is going to be a critical example of wage negotiations undertaken when the prospects for the motor-car industry are at least temporarily less bright than they were a few months ago. It will be highly instructive to see how the bargaining goes when more difficult trading conditions are not merely a threat to be held over the negotiating table but a stark fact.

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Virtue or Necessity?

When the first round of announcements was made just before Christmas that standstill arrangements on prices would be introduced in certain industries, we commended the move. Any constructive attempt to stop the interminable race between costs and prices is to be welcomed. It will be recalled that the initiative was taken by the cement makers and the plasterboard manufacturers. Quite a number of other companies have followed suit.

Their example should be followed. The time must soon come, however, when some of the larger industries, including certain basic industries, will have to follow suit if the gesture is to have any really practical effect. In this connection it is worth emphasising that there are some industries, and publishing is one of them, which are forced to hold their prices over long periods without having any defence against rising production cost. Advertising rates are often binding for a year, regardless of changes in costs. For years newspapers, magazines and books have fought a rearguard action against steeply rising paper, printing and binding costs. This willingness to keep prices steady used to be a source of pride in the engineering industry. Escalator clauses about prices in contracts would have received short shrift from earlier, sterner generations of engineers. The easy-going, fatalistic way in which costs are passed on by some of the industries subject to public control is also a soft option for the business executive of to-day. We still commend the example of standstill prices but if and when the move becomes popular, many companies will be doing only what some are already obliged to do and what their own predecessors would have considered a necessity rather than a virtue.

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Car Rumours on Clydeside

There have been reports that Scottish interests on Clydeside are becoming seriously interested in Mr. Harry Ferguson's new car. The Scottish Council (Development and Industry) have been trying to stimulate interest in Scotland for many years in developing a stake in the motor-car industry but this is the first time that discussion has taken such a tangible and promising form. Should these talks bring concrete results, Scotland will have passed a notable milestone in the widening of its industrial potential.

Discussion about the establishment of the motor-car industry over the border will bring a lump to the throat of many a Scottish engineer. In the early days of the motor-car industry, Scotland had such promising ventures as Argyll Motors and Arrol-Johnston. To-day nothing is left of these companies, although Scotland still has a large stake in the commercial vehicle industry. It has been one of the mysteries of Scottish industrial enterprise in the last half century that these promising developments in the motor-car industry (another example of a similar kind was the gramophone industry) died for lack of financial and managerial nourishment. Many who have studied the serious inability of Scotland to attract its share of the light engineering industry in the 1920's and 1930's have pointed to the early fate of the Scottish motor-car industry as an example of the unwillingness of Scottish industry to think seriously of projects outside well-worn grooves. Over the last 20 years there has been a change of attitude and to-day Scotland has a very significant proportion of recent developments in light engineering of all kinds. It would be a crowning achievement for those who have struggled in the last 25 years to bring about a greater diversification of Scottish industry, if they could replant a healthy motor-car assembly industry in the Clyde valley area.

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Institution Membership for Eminent Engineers

At a special general meeting of the Institution of Civil Engineers held on January 16, the Council routed an attempt to delete the by-law permitting admission to corporate membership by direct entry. It was proposed by 24 members that direct entry which allowed a man to be elected to full membership without having previously satisfied the Institution's examination requirements was a "back-door" whereby unsuitable applicants could purchase a qualification which they could otherwise not attain, so lowering the status of the Institution both within the engineering profession and with respect to other professional bodies. The answer put forward by the Council was a formidable one that was finally backed by four of every five votes cast.

An outline was given of the requirements demanded of a direct-entry applicant: that he should be an eminent engineer at least 50 years of age and have had 15 years of full responsibility on works of major importance following a period of training which the Council deemed to be satisfactory. The procedure adopted for scrutinising such applications involved perusal by each member of the membership committee; those applications thought to be suitable by the committee were then sent to the Council, who were only able to pass forward for publication in the Institution's bulletin the names of applicants thought to be suitable for admission. It was then open to any corporate member in the month following to submit objections to the Council if anything was known against a candidate. A considerable part of the Council's case was that not for many years had any such objection been received.

During the course of the debate it was made known that in the past five years the by-law had been successfully invoked on behalf of 28 candidates and that, of these, 22 were in possession of paper qualifications which could be considered as proper exemptions from the Institution's examinations. There was also before the meeting an amending resolution calling for a reconsideration of the by-law, and it was this procedure which was given the wholehearted support of the meeting.

It is indeed proper that the members should have given what in effect was a vote of confidence in their Council. There has to be some means available to the Institution to admit engineers of outstanding ability by direct entry and it is invidious to suppose that men of 50 and upwards should have to submit themselves to an examination designed for men of 25 or so. It was clear, however, that the existence of such a method of direct entrance required a most careful check of every application made under the by-law. Perhaps it will be thought desirable in the future to publish the names of such candidates for election with greater prominence than has been the case hitherto, for if the candidates are truly eminent the Institution should proclaim their entry into its ranks and, if they are not, then members will have no grounds for protesting that there had been no reasonable opportunity for resisting improper admission.

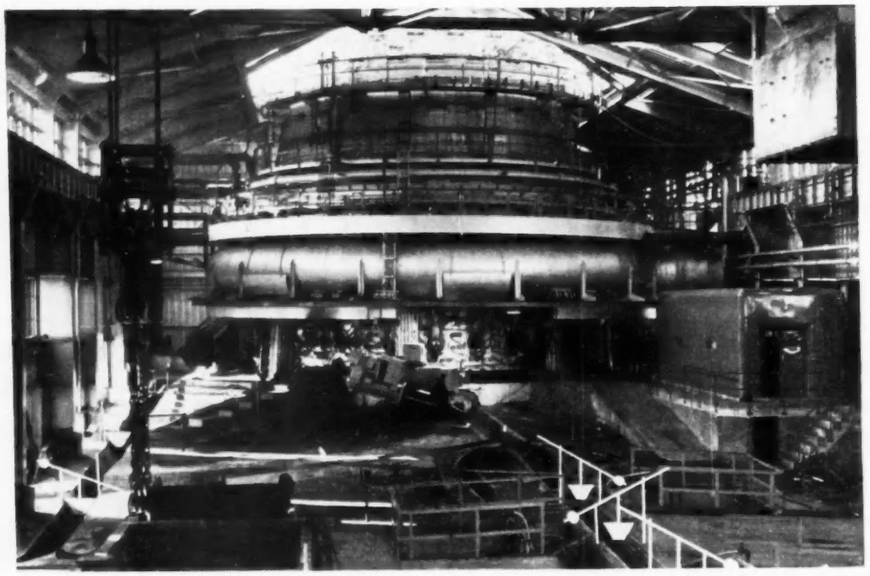

Fig. 1 Cast house of No. 4 blast furnace, showing tap hole, clay gun, and channels for directing the molten iron into ladles. The small structure on the right is the instrument house.

NO. 4 BLAST FURNACE AT MARGAM

Of late years the tendency in this country has been to build increasingly large blast-furnace plants to meet the ever-growing demand for pig iron. At the end of 1954 there were in existence in Great Britain 14 furnaces having hearth diameters of between 20 ft. and 22 ft. and eight having hearth diameters of over 22 ft. The latter comprised one of 22 ft. 6 in., at the works of J. Lysaght's Scunthorpe Works, Limited; two furnaces of 25 ft., one of 27 ft., and one of 28 ft. 6 in., at the Scunthorpe Works of the Appleby-Frodingham Steel Company, branch of the United Steel Companies, Limited (these being the famous Queen Mary, Queen Bess, Queen Anne and Queen Victoria furnaces); two of 25 ft. 9 in. at the Margam Works, Port Talbot, of the Steel Company of Wales, Limited, and one of 27 ft. at the Shotton Works of John Summers and Sons, Limited. In addition, several large blast furnaces have been under construction for some time, including one of 27 ft. at the works of John Summers and Sons, Limited, two of 27 ft. 6 in., at the works of Dorman Long (Steel), Limited, and a very large furnace of 29 ft. 9 in. at the Margam Works of the Steel Company of Wales, Limited.

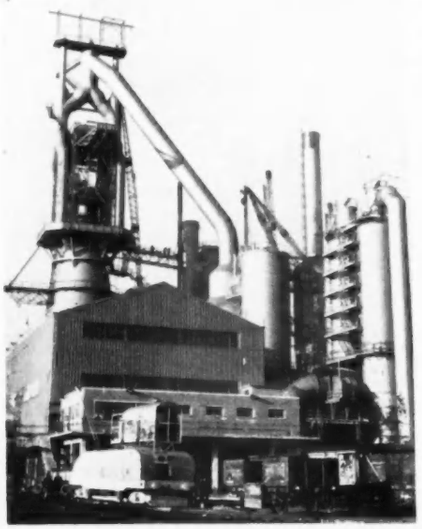

Fig. 2 General view of new No. 4 blast-furnace plant at the Margam Works, showing the gas-cleaning installation on the right. The vehicle in the foreground is a spare scale car. The furnace has a hearth diameter of 29 ft. 9 in. and a weekly iron-making capacity of over 10,000 tons.

The last-mentioned furnace has just been completed and was lit up by Mr. Harald Peake, chairman of the company, at an informal ceremony held on Tuesday, January 10. A general view of the furnace plant is seen in Fig. 2, while Fig. 1 shows the base of the furnace and the cast house. The furnace is stated to be the largest blast furnace in Europe and to have a daily iron-making capacity of 1,500 tons or upwards of 10,000 tons a week. It is designated the No. 4 furnace, the two mentioned in our first paragraph being Nos. 2 and 3 and the No. 1 furnace having a hearth diameter of less than 22 ft. The new furnace has been located on a new site on the south-west side of the Margam Works because of the limitation of the space adjoining the firm's three other furnaces. In the early days of its construction, considerable difficulties were encountered due to the nature of the soil substrata at the furnace site. Owing to the predominance of clay in the gravel bed, it was difficult to obtain a satisfactory set for the concrete piles employed, but this was overcome by pumping liquid cement into the gravel. After this operation, 445 piles were driven to support the 75 ft. diameter furnace foundation block.

The furnace, as stated above, has a hearth diameter of 29 ft. 9 in., it has a bosh diameter of 33 ft. and a throat diameter of 22 ft. 9 in. The height of the stack is 58 ft. 3 in., the height of the structure from the tuyeres to the stock line, 84 ft., the height from the hearth to the furnace decking 109 ft. 2 in., and the total height of the furnace 242 ft. The diameter of the large bell at the top of the furnace is 16 ft. 6 in. There are 21 tuyeres and the working volume of the furnace (from the tuyeres to the stock line) is 53,975 cub. ft. The hearth is lined with refractory brick while the side wall, up to the slag-notch level, is lined with carbon blocks. In all, some 1,500 tons of steel and 415,000 bricks have been used in the construction of the furnace.

Air for the furnace is provided by a 125,000 cub. ft. per minute steam-driven axial-flow turbo-blower supplied by the Oerlikon Engineering Company, Zürich, Switzerland. A view of the machine, taken during the construction period, is seen in Fig. 3. To preheat the air three stoves, each 140 ft. in height and 28 ft. in diameter are provided. The heating surface of the stoves is 330,000 sq. ft. and the control is fully automatic.

The furnace plant is equipped with four gas-cleaning units, each having a capacity of 2,660,000 cub. ft. of blast-furnace gas per hour.

The slag from the furnace will be run directly into pits alongside it, and, from these, the slag will be loaded by mechanical digging equipment into heavy road vehicles which will convey it to the slag tips. This arrangement differs from the method used on the other furnaces, where slag is run into ladles for conveyance to the tips.

RAW-MATERIAL STOCK YARD

The new furnace is furnished with its own stock yard, capable of holding 150,000 tons of iron ore. Ore from the works wharf and from a home-ore tippler reaches the new stock yard by way of an overhead conveyor and the distribution of the ore over the stock yard area is achieved by means of a stocking-out bridge. A reclaiming bridge is provided to lift ore from stock and deposit it on to a conveying system which carries it to the bunkers.

One of the scale or weighing cars which transmit pre-arranged quantities of ore from the bunkers to the skip car for charging into the furnace is seen in the foreground in Fig. 2. The scale-car track runs at ground level in order to facilitate cleaning and also to enable the car to be run directly to the central engineering shop if and when repairs are necessary.

The 90 new coke ovens needed to provide the extra coke required by the No. 4 blast furnace have now been brought into operation, the first coke having been pushed on January 6.

Bringing into service of these new coke-oven and blast-furnace plants will ensure that sufficient cast iron is available when two new open-hearth furnaces commence production in the Abbey melting shop of the firm during the next few months. This, in turn, will mean that steel will be available to supply hot-rolled strip to the Velindre Works when that plant comes into operation in the summer.

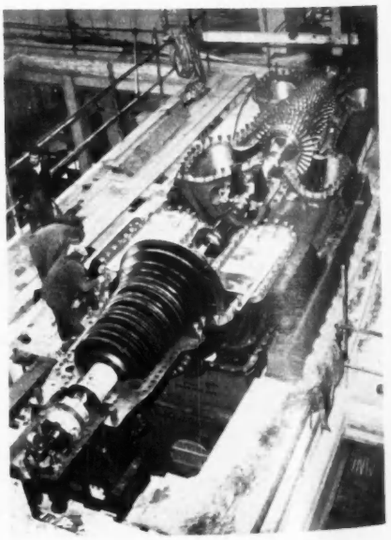

Fig. 3 Steam-driven axial-flow turbo-blower shown during the construction period. It supplies 125,000 cub. ft. of air per minute to the furnace.

ATTRACTING RECRUITS

FOUNDRY INDUSTRY'S CHALLENGING TASK

Mr. G. Lambert, secretary of the Institute of British Foundrymen, has said that the problem facing the foundry industry to-day is the shortage of technical men. That problem it shares with most other industries. How, then, does the foundry industry stand in this highly competitive manpower market?

The melting and casting of metals into the forms required by industry and commerce shares with the art of the blacksmith the distinction of being among the oldest of all the metal-working trades. As such it has had, in recent years, certain disadvantages in its efforts to attract suitable labour. Boys who might have taken up foundry work on leaving school have shunned it because they were told that it was hot, dirty and unpleasant. Some young men who might have decided to enter the technical side of foundry work have had a two-fold objection. They did not fancy doing the necessary practical training under conditions which they understood were bad, and they felt that the foundry industry was not only old but unprogressive.

Impressions such as these, which have been widespread in foundry areas like the Midlands, have not been without justification in the past. There were many foundries, particularly some of the smaller ones, where conditions were undeniably bad, and the rapid growth of welded fabrication, to mention only one development, tended to make castings look out of date. Both these factors, seen against a limited background by a boy about to commence his career, were often powerful deterrents, yet neither was representative of the true picture. As every engineer knows, the foundry industry is fully alive to modern ideas. The development of new techniques—the production of spheroidal-graphite iron is a good example—has enabled it to enter new fields where cast products were hitherto unknown. As for working conditions, certainly there are still some foundries where conditions are not what they should be, but of what industry is this not true? New regulations which came into force on January 1, 1956, impose on all foundries the obligation to provide a standard of working conditions and amenities which many of the larger concerns already provide in full.

All these things are known to the foundryman, and the engineer is fully aware of the fundamental importance of the foundry to the engineering industry, and therefore to the whole economic future of the country. It is unnecessary to preach to the converted; it is better to ask how much the general public knows of these matters, for it is from the general public that the foundrymen and technicians of the future will come. The foundry industry has some powerful competitors in its search for labour. Electricity, electronics, aeronautics and atomic energy in particular have the advantage of looking very modern and scientific, though it is true to say that none of them could exist without the help of the foundryman.

The industry has done, and is doing, much to inform the public of its aims and activities, but it needs to do more if it is to succeed in finding the labour it needs. Individually, and collectively firms in the industry have produced some excellent booklets on careers in the foundry, which present a true and unbiased picture of things as they really are, and an extension of this work could not fail to do good. Visits to foundries are also organised, and this, too, is a useful way of showing potential workers what goes on in a foundry. There is no better way than seeing for oneself, though of course nothing but a general impression, perhaps even a wrong impression, can be gained from a tour of a foundry lasting an hour or two.

The foundry industry might well try out the idea already put into practice by South Wales Switchgear Limited (ENGINEERING, September 2, 1955, page 293), of having a selected group of fifth-form schoolboys at the works for a whole week, and showing them what happens in considerable detail. This firm discovered that practically all the boys taking part in their scheme had no conception of what engineering shops were like, and that the week's work gave them an opportunity to judge for themselves. All the boys left the works realising the importance of craft training, and several who had previously never given a thought to the engineering industry decided that it offered good scope for a career. The foundry industry might find that such an experiment pays.

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ELECTRONIC COMPUTERS FOR STRUCTURAL ANALYSIS

Five Problems Resolved

At the Institution of Structural Engineers on Thursday, January 12, Dr. R. K. Livesley* presented a paper entitled "The Application of an Electronic Digital Computer to Some Problems of Structural Analysis,"† based on his work in this field while lecturing at Manchester University between 1951 and 1954. The principal structural problems so far solved by Dr. Livesley were of four types: the analysis of conventional building frames, taking account of direct loads in the members as well as bending; a floor slab supported on beams of variable stiffness; a steel skeleton with stability effects included in the analysis; and a simple structure designed by the method of plastic collapse in which the computer was used as an instrument of design to determine the optimum scantlings. The solution of a fifth type of structural problem, involving secondary stresses in a triangular framework was referred to by Dr. M. R. Horne who contributed to the discussion.

Describing the floor slab problem in which he had collaborated with Dr. R. H. Wood of the Building Research Station, Dr. Livesley reported that in a few hours continuous computing he had evaluated a series of 25 solutions of the biharmonic equations; such a computation would, he said, never have been undertaken manually as each of the solutions was based on the evaluation of a set of 49 simultaneous equations.

When asked whether the electronic computing method could be justified on cost, for use in professional engineering practice, Dr. Livesley said that he foresaw administrative difficulties in changing from one method to another, since a good case could always be argued for continuing with an existing method to solve the urgent current problems and leaving the next one to be tackled by the new method. However, he had no doubt that, once the initial difficulties had been overcome, the use of a computer, which could be hired by the hour, would be found economical.

Moving a vote of thanks, the President, Mr. Stanley Vaughan, said he could think of three classes of problems for which the electronic digital computer could be used with advantage by structural engineers. There was the long and difficult calculation which occurred occasionally on specially large or complicated designs; secondly, there were the routine problems in which the same type of problem had to be solved at frequent intervals; and there was also, as the author had pointed out, the design problem for which it was vital to find the most economical solution by repeating a particular computation in order to improve and refine a provisional design. Commending Dr. Livesley on having presented a paper which was of such great value to the structutal engineer, Mr. Vaughan welcomed the prospect of engineers being able to adopt these new methods of computation.

* Lecturer in the Engineering Department of Cambridge University.

† Dr. Livesley's paper is published in full in the *Structural Engineer* for January, 1956.

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THE LOUIS BREGUET MEMORIAL TROPHY

For Decreasing Speeds at Take-Off and Landing

To commemorate the French aviation pioneer Louis Breguet, Sir Richard Fairey, M.B.E., chairman and managing director of the Fairey Aviation Company, Limited, has presented to the Royal Aero Club a trophy, to be awarded annually by the Royal Aero Club for meritorious achievement in the development of any form of aircraft that substantially achieves the advantages of low take-off and landing speed offered by rotating-wing aircraft.

Louis Breguet, who died in Paris last year, devoted his early aviation activities to the design and development of helicopters. His Gyroplane, built with Richet in 1907, was the first helicopter in the world to lift itself into the air while carrying a pilot.

The Trophy is in the form of a silver statuette of Daedalus and Icarus, made by Mappin and Webb before the first World War; details of its history and original purpose were, however, destroyed by enemy action in 1940-41.

The Louis Breguet Memorial Trophy may be awarded to a manufacturing or operating company, an individual or individuals such as inventors, scientists or technicians, pilots or crews, provided that the recipients are a subject or registered organisation of the British Commonwealth and Empire or of France or her possessions. The award is to be made each February in respect of the previous year ended December 31. The first award will be for the year 1956. The Aero-Club de France will be requested to submit to the Royal Aero Club by January 31 in each year recommendations as to French subjects or registered organisations for the award; these are to be taken into full account by the Royal Aero Club before making the award. If no recommendations are received from the Aero-Club de France in any year the Royal Aero Club will make the award on the basis of British subjects or registered organisations only.

The award will be made for meritorious achievement in the development of heavier-than-air aircraft capable of taking off in still air at a speed not exceeding 30 km.p.h. (18·64 m.p.h.) when carrying full normal load, maintaining sustained flight, and landing in still air at a speed not exceeding 30 km.p.h. The award may be made in respect of meritorious development relating to aircraft in F.A.I. Classes C (aeroplanes), E (rotocraft) or H having the characteristics mentioned. Details of Class H are not yet available but they are expected to take account of vertical take-off aircraft.

The rules will be subject to revision from time to time so that they can take due account of future developments in the classes of aircraft of which the trophy is intended to encourage.

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RADIO TRADES EXAMINATION BOARD

The principal object of the Radio Trades Examination Board, which has now been granted incorporation by the Board of Trade, is the promotion of the technical training of radio mechanics and technicians by holding examinations leading to the award of Radio and Television Servicing Certificates. Nearly 100 technical colleges are providing a three-year part-time course for these examinations, for which 2,625 candidates have presented themselves since the war. Further details are obtainable from the secretary of the Board, 9 Bedford-square, London, W.1.

PERSONAL

LORD STRATHALMOND OF PUMPHERSTON, C.B.E., LL.D., is relinquishing the chairmanship of the British Petroleum Co. Ltd. on March 31 when he will have completed 33 years of service as a director. MR. B. R. JACKSON, the present deputy chairman, will become chairman and MR. N. A. GASS, C.B.E., M.C., will be made deputy chairman, as from April 1. It is also intended to appoint THE HON. M. R. BRIDGEMAN, C.B.E., to fill the vacancy on the board caused by the retirement of Lord Strathalmond.

MR. K. H. PLATT, M.B.E., B.Sc., M.I.Mech.E., has been made deputy secretary of the Institution of Mechanical Engineers, 1 Birdcage-walk, London, S.W.1. MR. F. H. HEARN, F.I.A.C., has been appointed assistant secretary.

PROFESSOR B. L. GOODLET, O.B.E.,M.A. (Cantab.), M.I.C.E., M.I.Mech.E., M.I.E.E., at present deputy chief engineer at the Atomic Energy Research Establishment, Harwell, has been appointed chief engineer and a director of the Brush Electrical Engineering Co. Ltd., as from April 1.

SIR GUTHRIE RUSSELL, K.C.S.I., K.C.I.E., B.Sc., A.M.I.C.E., has joined the board of directors of Henry Meadows Ltd., Fallings Park, Wolverhampton, a member of the Associated British Engineering group of companies.

The International Internal Combustion Engine Congress has formed a committee of experts to consider all technical matters, including papers, in connection with the Congress. MR. JOSEPH JONES, M.I.Mech.E., M.I.Mar.E., M.S.A.E., has been appointed United Kingdom representative on this committee. MR. J. G. WITHERS, B.Sc., M.I.Mech.E., is to be Mr. Jones's alternate.

MR. H. T. SAYER, engineer-in-charge of the Croydon establishment of the aeronautical division of Marconi's Wireless Telegraph Co. Ltd., Chelmsford, Essex, is to retire after 40 years of service with the company. His successor is MR. W. L. MUNDAY.

MR. H. W. KEMP has been appointed contracts engineer to the sales division of the Telegraph Construction and Maintenance Co. Ltd., Mercury House, Theobald's-road, London, W.C.1.

MR. B. A. HODGES, B.A.(Oxon), has been appointed secretary of the Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1.

MR. HENRY KNOWLER, A.M.I.C.E., F.R.Ae.S., technical director of Saunders-Roe Ltd., Cowes, Isle of Wight, is retiring shortly. He intends to continue his association with aviation as an independent consultant from his home address: Windward, Fishbourne, Isle of Wight. (Telephone: Wootton Bridge 62.)

MR. GEORGE JONES, general manager of Head Wrightson Stampings Ltd., has been appointed a director of that company.

MR. S. F. DERBYSHIRE is relinquishing his post as general production manager, the British Aluminium Co. Ltd., Norfolk House, St. James's-square, London, S.W.1, on reaching the retirement age on February 17. He will remain in a consultative capacity to the company for the time being. MR. W. B. C. PERRY-COSTE and MR. J. SALTER will assume the posts of joint general production managers as from February 17. MR. P. T. ENSOR has become general manager, and MR. A. R. WYLIE, works manager designate, of the Canadian British Aluminium Co. at Baie Comeau.

MR. J. B. MAVOR, chairman of Mavor & Coulson Ltd., Bridgeton, Glasgow, S.E., retired on December 31, 1955, after 35 years as a director. MR. J. D. LLOYD, sales director, joined MR. DAVID JACKSON as joint managing director as from January 1. MR. R. J. HIRD, director and chief engineer, has been appointed works director from the same date.

MR. H. MELHUISH, a director, has been appointed assistant managing director and head of the power-plant division of the Superheater Co. Ltd. MR. L. C. SOUTHCOTT, also a director, retains his position as chief engineer to the company but, in addition, has been appointed personal assistant to the managing director, MR. E. A. ROBINSON.

MR. A. L. SUTHERLAND and MR. H. C. WHITE have been appointed directors of Philips Electrical Ltd., Century House, Shaftesbury-avenue, London, W.C.2.

The Board of Trade announce that MR. JAMES ARCHDALE has resigned from the Monopolies and Restrictive Practices Commission on account of pressure of other work.

Capper Pass awards in respect of papers published in the *Transactions* of the Institution of Mining and Metallurgy and the *Journal* of the Institute of Metals, in 1954, have been made to MR. G. LAWRIE FAIRS (£100); MR. F. KING and DR. A. N. TURNER (£100); MR. G. L. HOPKIN, MRS. J. E. JONES, MR. A. R. MOSS and MR. D. O. PICKMAN (£50); and PROFESSOR M. REY (£50).

MR. GILBERT HUNT, who has been a director of High Duty Alloys Ltd., Slough, Buckinghamshire, since 1951, has been appointed general manager of the firm which is a member company of the Hawker Siddeley Group.

MR. H. E. HILL, chairman of Birfield Industries Ltd. and Laycock Engineering Ltd., has joined the board of Darwins Ltd. and their subsidiary companies.

MR. FRANK SPENCER, managing director of the Hotpoint Electric Appliance Co. Ltd., Peterborough, which incorporates the Coldrator and Premier divisions, has relinquished his executive position with the company in order to devote more time to the development of Opperman Gears Ltd., Newbury, of which company he has been a director for many years. He will remain a director of the Hotpoint Co. in an advisory capacity.

KENNEDY & DONKIN, 12, Caxton-street, London, S.W.1, announce that MR. H. HEADLAND, M.Sc. (New Zealand), M.I.C.E., M.I.E.E., A.M.I.Mech.E., who has been a senior member of their staff for some years, has been appointed a consultant to the firm.

MR. G. E. RICHARDS, branch manager of the Morgan Crucible Co. Ltd., Carver-street, Birmingham, is retiring on March 30, after 40 years of service. He will be succeeded on April 1, by MR. D. SCOTT, deputy branch manager.

MR. G. W. HESLETT and MR. MARCEL ZUBLIN have been appointed to the board of Sulzer Bros. (London) Ltd., 31, Bedford-square, London, W.C.1, as from March 1.

Automotive Products Co. Ltd., and their associated companies, Lockheed Hydraulic Brake Co. Ltd., and Borg & Beck Co. Ltd., have appointed MR. C. CLENCH, MR. C. HAYES, MR. A. R. W. MURRAY, MR. F. ROWARTH, MR. P. A. RIPPON, MR. J. K. SIMPSON, MR. H. UNSWORTH, and MR. D. J. WATKINS to be executive directors, as from January 1.

As a further preliminary step towards the restoration of the Steel Co. of Wales Ltd., to private enterprise, it has been decided that the company, in due course, will set up its own independent sales organisation. Accordingly, the HON. MICHAEL LAYTON, A.M.I.Mech.E., has been appointed sales controller of the Steel Co. of Wales. R. T. S. C. HOMES SALES LTD., and R.T.S.C. EXPORTS LTD., will continue to handle the company's sales until further notice.

MR. B. C. BAKER has been appointed sales manager, export division, London, to Leyland Motors Ltd., Leyland, Lancashire.

MR. L. H. S. HALLING, sales manager of A.P.V.-Paramount Ltd., stainless-steel founders, Manor Royal, Crawley, Sussex, has been appointed to the Board of directors.

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COMMERCIAL

Arising out of arrangements that have been made for the integration of trade association membership of the steam and Diesel locomotive manufacturers, the LOCOMOTIVE AND ALLIED MANUFACTURERS' ASSOCIATION (L.A.M.A.) has been formed as from January 1. The President is MR. T. A. CROWE (North British Locomotive Co. Ltd.), and the Council will comprise MR. J. F. ALCOCK (Hunslet Engine Co. Ltd.); MR. G. COLLINGWOOD, T.D. (Vulcan Foundry Ltd. and Robert Stephenson & Hawthorns Ltd.); MR. W. D. LORIMER (North British Locomotive Co. Ltd.); MR. C. C. H. WADE (English Electric Co. Ltd.); MR. W. J. WAKLEY (Drewry Car Co. Ltd.); and MR. H. WILMOT, C.B.E. (Beyer, Peacock & Co. Ltd.). The secretary is MR. G. R. CURRY, 82 Victoria-street, London, S.W.1.

THE DUNLOP RUBBER CO. LTD., have formed a new division which will be responsible for the manufacture and sale of hose in the United Kingdom. MR. P. A. BRIDGE has been appointed manager of the new division.

THE NATIONAL IRANIAN OIL CO. has taken over from the International Oil Consortium's two operating companies in Iran, the first of the "non-basic" operations for which they will gradually assume responsibility under the 1954 oil agreement. The take-over has been announced in Tehran by the two operating companies, the Iranian Oil Refining Co. and the Iranian Oil Exploration and Producing Co. Non-basic operations are those which are not directly concerned with the production and refining of oil, and the operations for which National Iranian Oil have become responsible are the m[illegible]cal and health services in the oil areas of South Ir[illegible].

VARLEY PUMPS AND ENGINEERI[illegible] LTD. are to change their name to VARLEY-F.[illegible]. LTD., Ferry lane, Brentford, Middlesex.

The address of the North-We[illegible] England and North Midlands office of WILD-B[illegible]FIELD ELECTRIC FURNACES LTD., Watford By-pass, W[illegible]ford, Hertfordshire, is now 1 Clarkehouse-road, [illegible]effield. (Telephone: Sheffield 62784).

TRIPLEX (NORTHERN) LTD., St. Helens, Lancashire, are to move shortly into a 66,000 sq. ft. building adjoining their present factory. The move will double their works area.

F. PERKINS (CANADA) LTD., a subsidiary company of F. PERKINS LTD., Peterborough, have moved into a new building on an industrial estate in Wingold-avenue Toronto, Canada.

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CONTRACTS

Arc Steel-Melting Furnace. The construction of a second arc melting furnace at the Stocksbridge, Sheffield, works of Samuel Fox & Co. Ltd., associated with the United Steel Companies Ltd., Sheffield, is shortly to be put in hand. It is to be a Birlec Lectromelt furnace, supplied by BIRLEC LTD., Tyburn-road, Erdington, Birmingham, 24, and will be larger than the existing furnace. Equipped with a swing roof and 20 in. diameter electrodes, the new furnace is to have a shell diameter of 20 ft., a transformer capacity of 20,000 kVA and will be provided with on-load tap change gear. The two furnaces will be housed in the same building and will have a joint pouring capacity of about 150 tons.

Electricity Generating Equipment. A contract for the supply and installation of equipment for the new Chopan steam power station, near Mirzapur, in the United Province, India, has been entrusted by the Electricity Department, United Provinces Government, to BRUSH EXPORT LTD., Loughborough, a member of the Brush Group Ltd. The order is valued at £360,000 and the equipment to be installed includes two 3,000 kW M.C.R. Brush-Ljungstrom radial-flow turbo-alternators, generating at 6,600 volts, three-phase, 50 cycles, and two JOHN THOMPSON "Integral"-type water-tube boilers having a maximum continuous rating of 45,000 lb. per hour, and a pressure of 425 lb. per square inch gauge at the superheater outlet at a temperature of 775 deg. F. The feed temperature is 210 deg. F. Chopan steam power station will be connected, through 3,000 kVA transformers, to a 33 kV transmission line to the Rihand Dam Diesel power station, also designed and equipped by Brush Export Ltd.

Television Apparatus. Following upon a contract announced in August, 1955, for the supply of all the transmitting and aerial equipment for the two Australian Government-controlled television stations, MARCONI'S WIRELESS TELEGRAPH CO. LTD., Chelmsford, Essex, now state that two further large orders have been received from their associated company in Australia, Amalgamated Wireless (Australasia) Ltd. The new orders have been placed by two independent Australian television companies. The total value of the firm's television equipment to be exported to Australia on these three contracts is upwards of £500,000.

Herald-Sun Television Ltd. have ordered a 10 kW vision transmitter, a 2½ kW sound transmitter, an aerial and feeder system, programme-input equipment, a combining unit, phasing and monitoring equipment and ancillary units. A three-camera outside broadcast vehicle and technical equipment for two studios are included.

Amalgamated Television services have likewise ordered a complete transmitting station which will be identical in all major respects with that of Herald-Sun Television Ltd.

Diesel Locomotives. Following a contract for two Diesel-mechanical locomotives for the Lea Hall Pit, the National Coal Board have placed orders for a further 5 locomotives with W. G. BAGNALL LTD., Stafford. All have 0-6-0 wheel arrangements and are suitable for 4 ft. 8½ in. track. Two locomotives will go to Hem Heath, one to Norton, one to Hilton Main and one to Littleton Collieries. The three locomotives for Hem Heath and Norton will be driven by NATIONAL [illegible]AA5 engines developing 208 h.p. at 1,400 r.p.m. They each weigh 28 tons and are capable of hauling trains of 1,000 tons gross weight on the level. The two locomotives for Hilton Main and Littelton Collieries are powered by M4A[illegible] engines.

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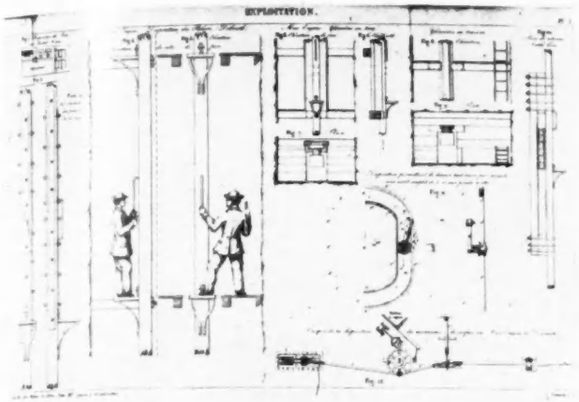

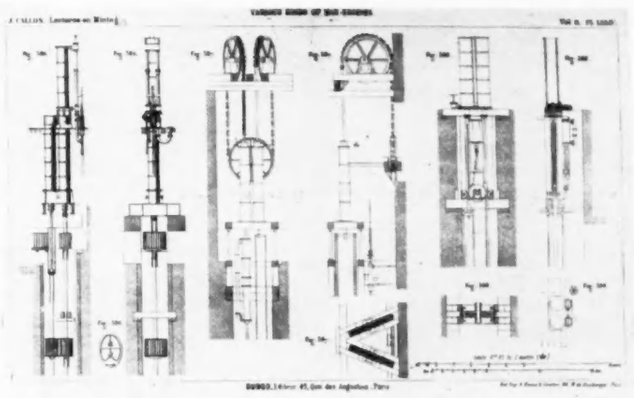

To eliminate the effort of climbing long ladders and also to reduce the time involved, the first mechanical lift was introduced. The illustration on the left shows the method of operation and that on the right some of the types that were evolved.

THE MAN ENGINE

EARLY MECHANICAL METHOD OF RAISING AND LOWERING MINERS

The man-engine is one of the lesser-known items of mining equipment, though it was once of considerable importance in some mining areas, and one or two examples were still at work in living memory. By relieving the miner of some of the physical effort incidental to his work, the man-engine was instrumental in prolonging the lives of large numbers of men; it was also, ironically, responsible for the worst accident in Cornish mining history.

Mr. David H. Tew, M.A., in his paper "The Continental Origins of the Man-Engine and its Development in Cornwall and the Isle of Man," read to the Newcomen Society in London on January 11, said that the man-engine could be described as an adaptation of an ordinary pump. In its simplest and final form, the single-rod engine, the rod, which was the equivalent of the pump rod, was provided with platforms at intervals on which a man could stand, and fixed platforms or "sollars" were installed in the shaft at the same distance apart as those on the rod. This distance was equal to the stroke of the rod. As the rod paused momentarily at each end of the stroke, a man wishing to use the man-engine stepped from a sollar to a platform on the rod. He then moved, up or down as the case might be, with the rod until he was opposite another sollar, when he stepped off the platform to the sollar. By repeating this process the man could travel steadily up or down the shaft with very little exertion.

GERMAN ORIGIN

Mr. Tew traced the origin of the man-engine to the Harz Mountains in Germany where by the 1830's the mines had reached a depth of 670 m., and the managements were concerned about the loss of time and the effect on the health of miners who were compelled to climb up ladders from the bottom of the shaft. The credit for installing the first man-engine is due to Herr Doerell, who, in 1833, adapted a surplus waterwheel-driven pump for raising men from a depth of 200 m. at Zellerfeld in Prussia. Other machines, some showing variations in design, followed, and the idea was also taken up in Bohemia, Belgium and France. All the Continental man-engines, and the first two in Cornwall, were of the two-rod type, a more complicated form than that in which the machine developed finally in this country. In the two-rod type both rods had platforms, and the miner crossed from one rod to the other alternately as he travelled in the shaft. This type of man-engine was not entirely satisfactory, being subject to a surprising number of accidents to the men riding on it, or else becoming too large and complex when attempts were made to improve it.

DEVELOPMENTS IN CORNWALL

Cornwall, like the Harz, had relatively deep mines, and Michael Loam, a well-known Cornish engineer, had tried without success to introduce the man-engine into the Consolidated Mines as early as 1829. It was not until 1841 that Tresavean Mine, one of the deepest in the county, installed the first man-engine in this country. It was only a small one, being built for trial purposes, but it was followed in 1842 by a larger machine which eventually went down to 290 fathoms. The development of the man-engine in Cornwall was stimulated by the Royal Cornwall Polytechnic Society, which took a great interest in the working conditions of the miners, and offered to pay £300 to the first mine with a man-engine down to 100 fathoms and proved in operation. A further sum of £200 would be paid when the engine reached 200 fathoms. By 1842 the Tresavean man-engine had reached the 100 fathom level, and the Society paid the promised £300.

Another engine was installed at the United Mines, Gwennap, in 1845, and then in 1851 Fowey Consols Mine built the first single-rod man-engine in Cornwall. It proved so successful that all subsequent Cornish man-engines were similar in general design. The single-rod engine was less expensive and occupied less space than the older type, it was safer for several reasons, and it could handle men at twice the speed. Man-engines were driven in various ways. Earlier ones were powered by waterwheels, later ones had steam engines to provide the motive power; often the engines were employed on other duties as well. The last man-engine to work in Cornwall, that at Levant Mine, was driven by a horizontal tandem compound steam engine installed in 1893 to replace an earlier drive.

On the whole the man-engine was highly successful, at least in the early years of its operation. Mine managements were enthusiastic about the saving of travelling time and the consequent additional time which the men could spend underground on each shift. Many reports of economies are typified by one from the United Mines, where it was said that the prime cost of the installation would be covered in 2½ years. Medical opinion in the mining areas was highly favourable to the man-engine, as was that of some of the Inspectors of Mines.

In the 1880's, however, different opinions began to predominate, and from that time on the number of man-engines in Cornwall diminished steadily. In 1895 there were only two left, the reduction in numbers being due partly to the closing of mines and partly to the substitution of cages and gigs. In the following year the sinking of a vertical shaft was started at Dolcoath, one of the two mines in question, and the use of the man-engine there was soon discontinued. The engine at Levant Mine continued to operate until October 20, 1919, when the cap of the rod broke, and let the rod fall into the shaft. The rod then broke at the 25 fathom level, and the top of the rod fell down the shaft, destroying the platforms as it fell. The rod was loaded with men at the time of the breakage, and no less than 31 lives were lost.

One other man-engine remained at work in the British Isles after the Levant disaster had brought the Cornish chapter to a close. This was at the Great Laxey Mine in the Isle of Man, where, at the suggestion of Dr. le Neve Foster, who knew the Cornish mines well, a man-engine had been put down in 1882. The Laxey engine worked until the mine closed in the 1920's, since when no man-engine has operated in this country.

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Colliery Winding Machine. Orders for two winding machines have been placed by the National Coal Board with the GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2. The first a double-drum electric winder will be installed at the No. 1 shaft of Cadeby Colliery in the Board's North-Eastern Division. The winder will have two drums, 16 ft. in diameter by 4 ft. wide, and is designed to raise coal from a depth of 2,280 ft., the drum speed being 46·9 r.p.m., and the hourly output 160 tons.

The second order is for two four-rope friction winders to be installed at the No. 6 shaft now being sunk at New Monckton Colliery, North-Eastern Division. Both winders have drums 10 ft. in diameter and will raise coal, at 10 tons per wind, the one from a depth of 1,065 ft. and the other from a depth of 1,545 ft.

Power Station Plant. Contracts have been placed by the Central Electricity Authority, during the months of November and December, 1955, for power-station, transforming-station and transmission line equipment amounting, in the aggregate, to £4,006,725. The principal contracts include:—for Po[illegible] power station: high and low-pressure pipework and valves, with AITON & CO. LTD., and two generator transformers, with FULLER ELECTRICAL MANUFACTURING CO. LTD. For Plymouth "B" [illegible]er station: Two 60,000 kW turbo-generators with the BRITISH THOMSON-HOUSTON CO. LTD. For Brighton (Southern Cross) sub-station: 132 kV switchgear, with the ENGLISH ELECTRIC CO. LTD. For Eastbourne substation: Two [illegible] MVA 132/11 kV transformers, with CROMPTON PARKINSON LTD. For Fleet substation: 132 kV [illegible]tchgear and 275 kV connections, with the METROPOLITAN-VICKERS ELECTRICAL CO. LTD. For [illegible]dale substation: 275 kV switchgear, with the ENGLISH ELECTRIC CO. LTD.

Obituary

SIR FELIX J. C. POLE

Railway Management and Electrical Manufacturing

Sir Felix Pole, who died on January 15, at the age of seventy-eight, though not an engineer, was closely connected with the railway branch of that industry as general manager of the Great Western Railway, and subsequently with electrical manufacture as chairman of Associated Electrical Industries, Limited, the Metropolitan-Vickers Electrical Company, Limited, and the British Thomson-Houston Company, Limited.

Felix John Clewett Pole was born at Great Bedwyn, Wiltshire, on February 1, 1877, and joined the Telegraph Department of the Great Western Railway at Swindon at the age of fourteen. He held a number of posts in this organisation in succession until in 1921, at the age of 44, he was appointed general manager. It was at this time that consolidation of the British railways into four groups was being considered, and although the necessary changes probably affected the Great Western less than other Companies, he played his full part in carrying out those which had to be undertaken. The " Castle " and " King " classes of locomotive were introduced under his regime and many of the services were improved by the inauguration of high speed expresses. In 1923 and again in 1930 he visited the Sudan, at the invitation of the Government, to report upon the railways and steamships in that country. In 1934, too, he reported on traffic conditions in Northern Ireland.

In 1929 he left the railway service to become chairman of Associated Electrical Industries, Limited, on its formation, as well as a director of the two main subsidiaries of that group—the Metropolitan-Vickers Electrical Company, Limited, and the British Thomson-Houston Company, Limited. He was appointed chairman of Metropolitan-Vickers in 1931 and retained this position until 1944, when he became vice-chairman. In 1946 he was appointed chairman of the British Thomson-Houston Company, a post he resigned in 1954. He had already relinquished the chairmanship of Associated Electrical Industries in 1945, but continued as a director until last year.

Sir Felix received the honour of knighthood in 1924. He was a member of a number of Government commissions and committees on various questions and had served on the Industrial Court.

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MR. A. L. MELLOR

Designer of Marine Engines

We note with regret the death of Mr. Alexander Leopold Mellor which occurred suddenly at his home in Glasgow on December 29. Mr. Mellor who was a director of Yarrow and Company, Limited, Scotstoun, Glasgow, W.4, was educated at the Boreman Foundation School, Greenwich, and subsequently studied at the Goldsmiths' Institute, New Cross, and at the People's Palace, Stepney. He commenced his engineering apprenticeship in the works of Yarrow and Company in Poplar on November 23, 1898, and after gaining experience in the manufacture of high-speed reciprocating engines, entered the London engineering drawing office of the firm in 1903. Mr. Mellor was associated with the changeover, in 1905, from quadruple-expansion engines for torpedo-boat destroyers, balanced on the Yarrow Schlick and Tweedy system, to steam-turbine propelling machinery.

Mr. Mellor came north with Yarrow and Company in April, 1908, and was closely connected with the design of the various types of machinery fitted to vessels constructed at Scotstoun, including destroyers for the British Admiralty and the Dutch, Danish, Portuguese and Yugoslav navies. In 1924 he was responsible for the design of the machinery of H.M.S. Ambuscade, one of the first destroyers to be fitted with independent cruising turbines for increasing the radius of action. Later, he was also responsible for the design of the Yarrow water-tube boilers fitted in the liners Queen Mary, Queen Elizabeth, Empress of Britain and other ships.

After the war of 1939-45, Mr. Mellor was associated with the introduction of advanced turbine and gearing installations in the Daring class ships Decoy and Diana, in steam frigates and other ships.

He was elected a director of Yarrow and Company in September, 1933, and when Pametrada was constituted in 1945 he was made a member of the Council. For the last five years he had been vice-chairman of the Association, but failing health led to his retirement in September, 1955.

Mr. Mellor was elected a member of the Institution of Engineers and Shipbuilders in Scotland in 1929.

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DR. F. SHERWOOD TAYLOR

Director of the Science Museum

The death of Dr. Frank Sherwood Taylor on January 5 at the age of 58 deprived this country, if not the world, of one of those scholars, far too few in number, who have developed the ability to interpret science in a language that the ordinary man can enjoy and the scientist can respect. Not for him the intellectual snobbery that would restrict an understanding of science to those who are able to devote full-time study to it.

In addition to his work at the Science Museum, London, where he had been Director since 1950, he wrote a number of books which will continue to serve a wide range of readers. His most recent work of this kind was *An Illustrated History of Science* in which, with illustrations by Mr. A. R. Thomson, R.A., he presented his subject in a lively and original manner.

Dr. Taylor was born on November 26, 1897, and was educated at Sherborne School, Lincoln College, Oxford, and University College, London. He was a chemistry master at various schools for 12 years, a period which doubtless impressed on him the need to counter the growing complication of science by a shrewder exposition of its nature. From 1933 to 1938, he was assistant lecturer in inorganic chemistry at Queen Mary College, London, and for ten years from 1940 he was curator of the Museum of the History of Science at Oxford, before taking up his appointment at the Science Museum in 1950.

Dr. Taylor was a governor of the Imperial College of Science and Technology, and a vice-president of the Newcomen Society.

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We regret also to record the deaths of:

MR. GEORGE LEVY, on December 20, 1955, at the age of 71. Since 1928 he had been vice-chairman of George Cohen Sons & Co. Ltd., the parent concern of the " 600 " Group of companies, and for many years had played a very active part in the development and administration of the George Cohen organisation. For a long period he served as chairman of K & L Steelfounders and Engineers Ltd., Letchworth, and T. C. Jones & Co. Ltd., London, Treorchy and Cardiff, both associated companies of the Group.

MR. SYDNEY JOHN YOUNG, B.Sc. (Birm.), M.I.Mech.E., at Bournemouth, on December 31, at the age of 68. He was for nearly thirty years head of the Department of Automobile Engineering of Loughborough College. Born in London on February 4, 1887, Mr. Young was educated at King's School, Warwick, and at the University of Birmingham. He joined the staff of the works engineer of the Daimler Co., at Coventry, in 1909 and two years later entered the drawing office of Wolseley Motors Ltd. In 1915 he became assistant to the chief engineer, and in 1921 was appointed lecturer in automobile engineering at Bradford Technical College. Mr. Young was made head of the Automobile Engineering Department at Loughborough in 1925 and retired some three years ago.

MR. ARTHUR EDWARD INGHAM, on January 9, suddenly at the age of 74. He was until recently joint managing director of George Richards & Co. Ltd., machine-tool makers, Broadheath, Altrincham, Cheshire. Mr. Ingham commenced his apprenticeship with George Richards & Co., in 1896, and eventually became general manager. He was elected a director in 1929. In June, 1953, he became consultant technical adviser and attended the works regularly until a few days before his death. He was also a director of Tilghman's Patent Sand Blast Co. Ltd.

MR. H. C. VAN DE VELDE, which occurred in Johannesburg, on January 14, at the age of 65. After serving in the 1914–18 war as Chief Wireless Officer to the Canadian Air Force he joined Marconi's Wireless Telegraph Co. Ltd., and was responsible for the installation of the first wireless station at Croydon Airport. He became joint sales manager of the company in 1929, and successively assistant general manager, and deputy general manager, being promoted to general manager in 1935. In 1936 he also became managing director of the Marconi International Marine Communication Co. Ltd. He served on the boards of the associated companies of the Marconi organisation in South Africa, Belgium, Norway and Italy, and in 1944 was appointed senior executive of the Marconi International Marine Communication Co. He had been president of the Comite International Radio Maritime and chairman of the Radio Marine Associated Companies. He retired last summer, but retained a consultative interest in the company's affairs.

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DYNAMIC CHARACTERISTICS

Cambridge Conference in April

A conference on " Plant and Process Dynamic Characteristics " has been arranged by the Society of Instrument Technology and will be held on April 4, 5 and 6, at the Engineering Laboratory, Cambridge. Delegates will assemble at 4.15 p.m. on April 4 and, after registration, there will be an introductory meeting and either a display of films or an informal discussion. Papers to be discussed during the following two days are expected to include " The Dynamic Response of an Experimental Jacketed Pan," by Mr. A. H. Horton; " The Distillation-Column Reboiler," by Mr. R. L. Day; " An Investigation of the Transient Response of a Distillation Column," by Dr. W. D. Armstrong and Mr. W. L. Wilkinson; " Response of Concentrations in a Distillation Column to Disturbances in the Feed Composition," by Dr. H. Voetter; " Dynamic Behaviour of pH-Glass Electrodes and of Neutralisation Processes," by Mr. M. W. Geerlings; " An Analogue Simulator Applied to the Study of an Operating Process Control Loop," by Mr. N. Ream, Mr. R. H. Tizard and Mr. D. S. Townend; " Measuring Dynamic Responses of Plant Units," by Mr. J. Endtz, Dr. J. M. L. Janssen and Mr. J. C. Vermeulen; and " The Woollen Carding Engine: An Experimental Investigation," by Mr. G. H. Thorndike, Mr. R. T. D. Richards and Mr. P. D. Jowett. There will be visits to laboratories and demonstrations of equipment on the afternoon of April 5.

All persons interested in the subject of the conference, whether members of the Society or not, will be eligible to attend, but the total number will be limited owing to the restricted accommodation and in order to maintain informality. Meals and accommodation will be provided at Pembroke College and the inclusive charge will be five guineas.

The secretary of the Society is Mr. R. D. Smyth, 184 Sherwood Park-road, Mitcham, Surrey, but applications to attend the conference should be addressed to the secretary, S.I.T. 1956 Conference, Engineering Laboratory, Trumpington-street, Cambridge.

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In the article on "Lift Modernisation at Thames Tunnels," which appeared on page 26 of ENGINEERING for January 6, it should have been stated that the work was carried out for the London County Council under the direction of Mr. J. Rawlinson, C.B.E., M.Eng., chief engineer, assisted by Mr. C. Belcher, M.I.E.E., and Mr. C. G. L. Mosley, A.M.Mech.E., A.M.I.E.E. We regret the omission.

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in ENGINEERING.

Materials Handling and Work Study Data. *College of Production Technology, Charing, Ashford, Kent.* (21*s.*)

These papers are the study notes compiled by the College of Production Technology to accompany their courses on work study and materials handling. The subjects covered comprise (1) materials handling, including basic principles and considerations, factory planning, conveyors, elevators, hoists and cranes, industrial trucks, palletisation, co-ordination of materials handling with production, choice of equipment, stores and stores handling, economic analysis and case studies; and (2) work study, including definition and scope, method study, work measurement, incentives and economic analysis.

Engineering Training for Women. By VERENA HOLMES. *The Women's Engineering Society, 25 Fouberts-place, London, W.1.* (2*s.*)

This booklet, which has been compiled with the assistance of the Careers Panel of the Women's Engineering Society, discusses the possibilities of an engineering career for women, and gives details of university training, apprenticeship and sandwich courses and scholarships open to women. The branches of engineering referred to in some detail comprise mechanical, aeronautical, heating and ventilating, electrical and civil. The final section deals with possibilities in research and draughtsmanship and design.

Tool and Cutter Grinding. By ROBERT S. CONNELL. *The Machinery Publishing Company, Limited, National House, West-street, Brighton, 1.* (17*s.* 6*d.*)

This is a volume in the standard reference series and describes the grinding of tools and cutters from practical aspects. In particular, chapters are given on twist drills, milling cutters, broaching and gear cutting tools, and cemented carbide tools. Reference tables at the end give clearance angles and grinding wheel speeds and other information.

Spectrochemical Abstracts. Vol. IV: 1946-1951. By ERNEST H. S. VAN SOMEREN and F. LACHMAN. *Hilger and Watts, Limited, 98 St. Pancras-way, London, N.W.1.* (30*s.*)

The subject matter of this work is divided into two main parts, the first dealing with authors and references, arranged alphabetically under the authors' names and including also an index to elements in samples, and the second part with the abstracts themselves. The first three volumes of the series contained abstracts which were numbered consecutively; hence the present volume begins with No. 863. The substances analysed comprise biological materials, ceramics and slags, gases, oils, liquids, minerals, non-metallic solids, and metals and alloys. Other abstracts relate to apparatus, methods, source theory, wave-length tables and atlases, reviews and summaries and books.

The following reports may be obtained from the British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey:

Polarization of Dielectrics by Slow Particles, III. By H. PELZER. No. L/T316. (7*s.* 6*d.*) An expression for the dissipated energy, taking into account electronic as well as ionic polarisability, is derived from an expression due to Fröhlich and Platzman by a short method, made possible by a delta function relation of Gross and Pelzer. The expression for electric energy and other relations are derived phenomenologically from the dispersion law for the permittivity. Based on this, an outline for a correct calculation of the energy carried along with the particle, to replace that of report L/T184, is briefly indicated, but not carried out.

Failures of Earth Wires on a 33-kV Overhead Line System. By F. BUSEMANN. No. O/T15. (6*s.*) Calculations have been made to assess the possibility that frequent failures in steel earth wires on a 33 kV steel tower overhead line system were caused by overheating of the earth wire due to excessive current in the spans adjacent to an earth fau

Design of High-Voltage Stress-Controlled Condenser-Type Bushings and Capacitors. By S. SILBERMANN. No. Q/T[illegible]. (30*s.*) This report deals with the development of a general theory of the design of stress-controlled condenser-insulators, such as condenser bushings and high-voltage capacitors, and with application for practical purposes. The main part of the report shows the application of the formulae to the practical design and the calculation of the main dimensions and of the conducting layers in condenser-bushings and high-voltage capacitors.

Design of High-Voltage Stress-Controlled Condenser-Type Bushings and Capacitors. Concise Report. No. Q/T123a. (18*s.*) This shortened version of report Q/T123 gives the formulae and curves required to design condenser-type bushings and capacitors, with sufficient explanation to enable them to be used, but excludes the theoretical derivations of the formulae.

Performance of Joints in Steel and Non-Ferrous Conduit and Fittings (Excluding Copper). By L. GOSLAND. No. V/T119. (18*s.*) Tests have been carried out on the maintenance of electrical continuity of screwed joints between various metals and steel, both at the E.R.A. Laboratories and by the Department of Development and Research of Tube Investments, Limited.

Investigation of Deterioration of Moulded Carbon Resistors: Second Report. By J. J. WALSH and H. F. CHURCH. No. Z/T96. (12*s.* 6*d.*) This report is a continuation and expansion of an earlier report, A/T92, the resistors investigated being from two manufacturers. The life tests show that long life is dependent upon thorough wax impregnation, and that the physical and chemical stability of the wax used is of great importance. Drying out under load may cause initial changes with some resistors.

A Company's Story in its Setting: Samuel Williams and Sons, Limited, 1855-1955. *Samuel Williams and Sons, Limited, 8 Lloyds-avenue, London, E.C.3.* (No price given).

Samuel Williams and Sons, Limited, have celebrated their centenary by publishing this volume entitled *A Company's Story in its Setting*. In order to trace the expansion of this family concern from its early beginnings as a lighterage business on the Thames, four eminent authors have contributed essays on changes in the last 100 years: changes in East London, in British engineering, the pattern of enterprise, and in industrial welfare. For many years now the company has owned and operated one of the largest private docks on the Thames and has been engaged in water, road, and rail transport. From this beginning the company has had its own civil and mechanical engineering departments for the maintenance of the barges, docks, locomotives, road vehicles and dock-side equipment, for the construction of premises, etc.

F.B.I. Register of British Manufacturers, 1956. 28th edition. Published for the Federation of British Industries by *Kelly's Directories, Limited, 186 Strand, London, W.C.2*, and *Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1.* (42*s.*)

As before the two largest sections of the *Register* consists of a classified buyers' guide to the products and services of the 7,300 member firms of the Federation, and an alphabetical directory of these firms. Other sections comprise French, German and Spanish sections and language glossaries and lists of trade associations, boards, trade names and trade marks. Details of the organisation, aims and activities of the Federation are also included.

The Automatic Factory: What Does it Mean? *E. and F. N. Spon, Limited, 15 Bedford-street, London, W.C.2.* (30*s.*)

This is a report of the conference held by the Institution of Production Engineers at Margate, June 16 to 19, 1955. The conference was reported in ENGINEERING, June 24, 1955.

Fire Protection Year Book, 1956. Compiled by GEOFFREY F. D. PRATT. 16th edition. *Benn Brothers, Limited, Bouverie House, Fleet-street, London, E.C.4.* (12*s.* 6*d.*)

As in previous editions, the subject matter of this *Year Book* is divided into eight sections. The first constitutes a directory of public fire brigades and salvage corps in the British Isles and Section II a directory of industrial and private fire brigades. Section III relates to the fire services of the Commonwealth and Empire, while Section IV contains details of Civil Defence authorities and officers. Section V deals with Government departments and public authorities concerned with fire prevention and Section VI with associations and societies interested in, or connected with, fire fighting and fire prevention. Sections VII and VIII are concerned respectively with the legal aspects of fire safety and with fire-engineering technicalities and statistics.

Instruments for Measurement and Control. By WERNER G. HOLZBOCK. *Reinhold Publishing Corporation, 430 Park-avenue, New York 22, N.Y., U.S.A.* (10 dols); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (80*s.*)

This book discusses the design, construction and operation of instruments for measuring and controlling temperature, moisture, pressure, flow, liquid level, density, viscosity, speed and analysis, in non-mechanical terms. Electric controllers, self-operated pneumatic and hydraulic controllers are described, as are also time function controllers and final control elements. The final chapter discusses trends towards automation. The book includes a glossary of technical terms.

Industrial Furnaces, Vol. II. By W. TRINKS. Third edition. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (10 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (80*s.*)

In this third edition of volume II of his work, Professor Trinks brings his readers abreast of advances made in the field of industrial foundries since the second edition of 1941. While volume I, now in its fourth edition, discusses the basic principles underlying furnace design and operation, volume II deals with fuels and electrical energy, combustion devices and heating elements, the control of furnace temperatures and atmospheres, labour-saving devices, a critical comparison of fuels and of furnace types, and safety measures in the handling and use of fuels and in the use of electrical energy. The general arrangement of the subject matter is identical with that adopted in the second edition, but the chapter on safety measures is new.

The Technology of Cement and Concrete. Vol. I: Concrete Materials. By ROBERT F. BLANKS and HENRY L. KENNEDY. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (11 dols.); and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (88*s.*)

The present book is the first of a two-volume work on the technology of cement and concrete, based on lectures given by the authors at the Harvard University Graduate School of Engineering. Volume I is concerned with the source of materials, in particular the manufacture of Portland cement and the selection and treatment of the aggregates. Problems of design of mixes and concrete placing are left for volume II.

Flood Estimation and Control. By B. D. RICHARDS. Third edition revised. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (35*s.*)

One of the main purposes of this book is to analyse in detail the principal factors affecting flood discharge and to assess the relative importance of these factors and the effect of their interconnection. It is largely based on two papers presented by the author to the Institution of Civil Engineers in 1937 and 1939 and published in that Institution's journal. This third edition contains a review of the disastrous flood at Lynmouth and a new section on the unit "hydrograph" method of flood estimation. A fuller development is also given of the author's approximate method of calculating the flood absorption effect of a reservoir.

Production Control and Related Works Statistics. Issued by the Joint Committee of the Institute of Cost and Works Accountants and the Institution of Production Engineers. *Gee and Company (Publishers), Limited, 27-28 Basinghall-street, London, E.C.2.* (5*s.*) (See Weekly Survey in this issue.)

Into the Water Barrier. By DONALD CAMPBELL, in collaboration with ALAN W. MITCHELL. *Odhams Press, Limited, Long Acre, London, W.C.2.* (15*s.*) (Reviewed on page 42, in the issue of January 13.)

Strength of Materials. By BEVIS BRUNEL LOW. Second edition. *Longmans, Green and Company, Limited, 6 and 7 Clifford-street, London, W.1.* (18*s.* 6*d.*) (Reviewed on page 42, in the issue of January 13.)

Shop Theory. Prepared by the Shop Theory Department of the Henry Ford Trade School, Dearborn, Michigan. Revised by FRED NICHOLSON. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (4·50 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (34*s.*) (Reviewed on page 43, in the issue of January 13.)

The Supervision of Civil Engineering Construction: Including the Preparation of Contract Documents. By A. C. TWORT. *Edward Arnold (Publishers), Limited, 41 Maddox-street, London, W.1.* (25*s.*) (Reviewed on page 43, in the issue of January 13.)

Zahnräder und Zahnradgetriebe. *Friedr. Vieweg und Sohn, Burgplatz 1, Braunschweig, Germany.* (24.50 D.M.)

This work of 266 pages is a symposium of articles, lectures and subsequent discussions relating tooth wheels and gears. It deals with the strength of teeth, the hardening of the surfaces, the displacement of profiles, the use of synthetic materials, reports on experiences relating to methods of hardening of surfaces, a report on experiments with gears for marine use, and the measurement of noise.

Book Reviews

RISE OF THE HELICOPTER

Principles of Helicopter Engineering. by JACOB SHAPIRO. *Temple Press, Limited, Bowling Green-lane, London, E.C.*1. (55*s.*)

The idea of vertical flight has been pursued by man through the ages. Schemes, wild and practical, have appeared since the days of da Vinci. Early in the Twentieth Century efforts were redoubled with the advent of the petrol engine and its promise of light power plant. But none was successful because sufficiently light and powerful engines to lift the machines were not available. Thus, the initial flights were with fixed-wing aircraft which required less power at their minimum speed.

In the 1920's the autogyro was pioneering the way to realising the dream of providing rotating wings for lift in flight, though hovering was not possible. But most of the foundation of the theory and practice of rotating wings was laid by the vital work of Cierva in this era. In the late 1930's practical helicopters began to appear in various countries, for example. France (Breguet), Germany (Focke), Great Britain (Weir) and U.S.A. (Sikorsky). The war extinguished the French and British efforts, but operational German helicopters were made, and above all the American Sikorsky line of successful helicopters was launched.

After the war there were almost frenzied efforts by designers to build and fly their pet theories of helicopters aimed at any need between the giant weight-lifting crane and the one-man runabout. Rotor layouts were legion, ranging from the classical (or Sikorsky as it is sometimes known—a graceful recognition of Igor Sikorsky's major contribution) through twin-intermeshing, overlapping, coaxial, tandem, side-by-side to multi-rotor arrangements of three or more main lifting rotors. Rotor control and stability problems were tackled with zeal and ingenuity and some success. Propulsion was mainly by reciprocating piston engine through mechanical transmission, though various forms of tip jet propulsion were pursued—possibly sparked off by the Doblhoff pressure jet in Austria towards the end of the war. The later advent of the gas turbine and the rocket has added other possible and very attractive forms of supplying power to the rotor. The Korean war highlighted the value of the helicopter in a dramatic way and the U.S. Services quickly realised its major possibilities. This had the effect of channelling design effort along the lines adopted by the more successful firms. Many of the immediate post-war designs languished and died—some deservedly so.

At the moment, most helicopters are mechanically driven and are still of the classic configuration (because they are built by Sikorsky), though the twin tandem arrangement is also present in force. The major new developments are in the field of propulsion and towards the goal of higher speed, since the novelty of being able to hover and all it implies having worn off, users demand greater efficiency for the helicopter as a transport vehicle. Hence the demand for speed. Such then is a drastic condensation of the chequered history of development of a fascinating new vehicle which, now it has arrived, has to justify itself in everyday useful service against keen air and surface competition.

Research, design and manufacturing organisations both large and tiny have been seriously handicapped by the lack of satisfactory textbooks on the new ground to be tackled by the younger entrants in the profession. The requisite knowledge is often available—if one knows just where to look in the scattered technical literature of many countries—but this hunting process is wearisome and is frequently not even tried, so large seems the task. In fact, so bad was the situation that one major U.S. company actually charged a leading rotating-wing specialist, then a staff member, to turn a series of staff lecture notes into the form of a book. So acute was the need that this book spread far beyond the original firm and became one of the few texts on the subject. Later an excellent book, also American in origin and dealing with helicopter aerodynamics, appeared and went a long way to meeting a hungry demand in this corner of the field.

It is against this background of a growing industry (complete with the associated pains!) devoted to building a vehicle with a complex and somewhat mysterious lifting and control system, that Mr. Shapiro's book must be examined. That it amply fulfils a pressing need there is no doubt. The author covers almost every aspect of helicopter design, with the theory and performance of the rotating wing in steady flight, blade dynamics, blade loading and deformation, force and vibration on the blades, stability and control of single and multiple rotors, design requirements, types of rotor and control systems, fatigue, power plant and structures. Indeed a comprehensive field.

The scope, value, and general standard of the first two-thirds of the book, covering performance, dynamics, forces and vibrations, stability and control of rotors, are high in spite of occasional inaccurate references to figures. The work is painstaking and thorough, though there are some statements which are open to question. On page 101 it is asserted that gear transmission losses are 1 to 1½ per cent. per tooth contact depending on the type of gear. However, by using ground gears these losses have been kept to about ½ per cent., a quite significant difference. The paragraph on gas turbines (2.2.3, page 103) could have been expanded with advantage to demonstrate the problems inherent in direct coupling of a fixed-shaft turbine to a rotor. Hence the advantages of the free turbine—of which there are examples of a size suitable for helicopters (e.g., the Napier "Gazelle")—could have been more convincingly demonstrated.

The latter third, beginning with the design requirements, does not maintain the initial high standard and the impression gained is that the author had tired somewhat of the monumental task he had set himself. It would probably have been better to have treated the chapters on articulation and hub of the lifting rotor, and on the flying controls, more comprehensively at the expense of the remainder. Fortunately, however, the meat of the book and the parts of most general value in a major text-book are the first two-thirds, where the treatment is appropriate. General criticisms which might be made are that the quality of the figures is very patchy. For example, an excellent drawing of the Bristol hub appears in Fig. 6.2.1.3 (the decimal classification has run riot in the book), but by comparison, Fig. 6.2.5.6, presumably of the American Helicopter Company's "Jet Jeep," is practicably indecipherable. A drastic improvement of the offending drawings, diagrams, and graphs is needed for any second edition. Titles to the figures would be helpful instead of asking the reader to cross-refer to the text for the information, especially as an identical four-figure decimal system is used for figures, equations, and bibliography. Considering the very wide scope of the work, the bibliography is not very extensive and reference to some of the extensive collected bibliographies would have been useful. Similarly the index could be increased with advantage.

However, none of these relatively minor criticisms fundamentally affects the belief that this is a most valuable contribution to the scanty literature of a subject which was in desperate need of such a book.

PRECISION MASS PRODUCTION OF SMALL TURNED PARTS

Swiss-Type Automatics. Parts 1, 2 and 3. By G. A. W. MORGAN. Nos. 36, 36a and 36b of the Yellow Back Series. *Machinery Publishing Company, Limited, National House, West-street, Brighton*, 1. (4*s.* each).

The Swiss-type automatic lathe was developed in Switzerland for the watch and clock industry, and it is now well known in this country and many others for the production of small, high-precision turned components. The machine is made in various forms and in more than one country besides Switzerland, but all the makes and types have certain basic characteristics in common. In principle the Swiss-type automatic consists of a sliding headstock and longitudinally-fixed tool-holders. Bar material is rotated to provide the required cutting speed, and at the same time the complete headstock and spindle assembly carrying the bar is moved axially to provide the necessary longitudinal motion for turning. The tools are disposed radially within a semi-circle around and above the axis of the work, and are arranged for movement at right angles to the work only.

The principles of bar and tool movement being common to every type and make of Swiss-type automatic, it is possible to discuss them at length without reference to any specific machine, and this is done in the introduction to the first of the three booklets. From a consideration of the headstock and tooling equipment the author proceeds to discuss tooling and process planning for some typical components, commencing with a number of simple but very necessary basic considerations. Not the least important of these is that of suitability. The Swiss-type automatic is not intended for large-scale metal removal; there are other machines designed for that purpose, and Swiss-type layouts should be prepared on the basis of high speeds and low feeds.

The last part of the first booklet in the series is devoted to a consideration of seven typical Swiss-type machines: the Swiss-made Bechler, Petermann, Tavannes and Tornos; the American Gibbs and Gorton; and the British Wickman machines.

In the second of the three booklets the author deals with attachments which can be fitted to the Swiss-type automatic machine for carrying out machining operations other than the basic one of turning. Such work as centring, drilling, reaming, threading, recessing and slotting can be done by the use of attachments to the machine, the operations being incorporated into the production cycle. The attachments conform to certain general principles, but often vary considerably in detail between different makes. The booklet deals, in separate chapters, with single-spindle drilling attachments; two and three-spindle attachments; slotting, undercutting and taper attachments, and special devices for several purposes. A chapter on layouts involving the use of attachments follows, the machining cycles being broken down fully in tabular form.

The third of the booklets is devoted to a study of cam layout and design of tools for a number of typical components, the operations being tabulated in detail. The booklet is not claimed to be exhaustive, but the treatment of the different components chosen as examples is detailed, and a wide range is covered. Each of the examples is treated in the same way. A drawing of the component is provided, and the basic processes for the production of the article are listed. The operations are then tabulated in detail, followed by a description of

the method of preparing cam and tool detail drawings.

Each of the booklets is self-contained, though the series of three is complementary and intended to be read and used as a single volume. The text is simple and straightforward, and the author has presented a considerable amount of detailed technical information in a small space by avoiding anything which might be considered superfluous. On the other hand the work does not suffer from over-condensation. All three booklets are well illustrated by reproductions of photographs and drawings, and each has an independent index.

NOISE IN ELECTRONIC DEVICES

Noise. By ALDERT VAN DER ZIEL. *Prentice-Hall, Incorporated*, 70 *Fifth-avenue, New York, N.Y., U.S.A.* (7.50 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.2.* (60*s.*)

One of the most striking manifestations of spontaneous fluctuation—the Brownian movement—was first reported in 1828, but it was not studied theoretically until 1905 by Einstein. It was subsequently realised that random molecular bombardment would ultimately intervene to set a natural limit to the sensitivity of all measuring processes, though the knowledge was of comparatively little practical significance, as this limit was then far from attainment. But rapid improvements in experimental technique and the vast increase in the use of electronic devices of all kinds during the past thirty years have made the study of spontaneous fluctuations, and particularly those affecting currents and voltages in electrical circuits, a matter of lively concern to the electrical engineer.

These spontaneous fluctuations seriously restrict the practical possibility of detecting weak signals and, as they most commonly manifest themselves as an audible background hiss in receivers, the electrical engineer simply refers to them as "noise" despite the fact that, if they are to be regarded as truly random events, their frequency distribution will be a continuous one and not confined to the audible range. Fluctuation noise is inevitable because an electric current, in fact, consists of a procession of charged particles and cannot be treated as a continuous flow of fluid. These individual current carriers are usually electrons. Their random motion within a conductor gives rise to thermal noise, their random liberation from a thermionic or photo-electric cathode causes what is known as the shot effect, while the slower and more considerable fluctuation, probably due to irregular changes in the work function affecting small areas upon the surface of oxide coated cathodes, is termed the flicker effect or excess noise. Multigrid tubes also exhibit partition noise arising from random variations in the relative proportions in which the space charge current is shared between the respective collecting electrodes.

Although probability considerations are basic to any attack on noise problems it is not until nearly three-quarters of the way through the text that any detailed consideration is given to statistical methods and the Fourier analysis of fluctuating quantities. Had these two chapters (in which, as also in the index, Stirling appears as Sterling) been inserted at the beginning, a considerable number of references ahead could have been avoided.

Nyquist's theoretical treatment of thermal noise is considered first. His resulting expression is shown to admit of experimental verification and to be applicable not only to ordinary passive circuit elements but also to electromechanical and electroacoustical systems, in all of which the thermal noise at a uniform temperature T can be completely described by substituting for the components concerned the corresponding equivalent electric circuits at the same temperature. After introducing a number of practical quantities that are employed to define the noisiness of networks and amplifiers, a careful analysis is carried out of the noise figure of receivers. This is followed by a most useful chapter on noise measurements. Noise powers are most simply measured with the aid of a linear amplifier in conjunction with a quadratic detector. Practical hints are provided concerning the design of noise amplifiers and thermal noise sources and on the factors affecting the choice of detectors, and it is shown how noise measurements can lead to an absolute determination of temperature.

Tube noise, for which the shot effect is mainly responsible, is considered at low and high frequencies. Schottky's theorem is derived and space charge is shown to be capable of exerting a considerable smoothing effect. Multigrid tubes are treated by sub-dividing them into a number of equivalent diodes. Noise due to secondary emission and to collision by ionisation is considered, together with the causes of noise in photo-cells. The discussion of noise at high frequencies is based on the Llewellyn-Peterson equations. The relative merits of various practical low noise circuits are then considered and here, as elsewhere, the representative values quoted are a most welcome and valuable feature. The discussion of excess noise in semi-conductors and vacuum tubes is prefaced by a brief outline of solid state theory and includes information on noise in crystal diodes, transistors and photo-conductive cells.

Two chapters deal with noise in mixer tubes and circuits, which is more pronounced than noise in amplifiers, and with noise in feedback circuits, which are sometimes erroneously stated not to alter the noise figure. Chapter 13 is devoted to noise in detector circuits, Chapter 14 to vacuum tube electronics and Chapter 15 to space charge waves in electron beams. The concluding chapter discusses noise in physical instruments, first in a general manner and then in more detail as exemplified in radiation detectors, counters, galvanometers, and electrometer triodes as well as in alternating-current methods for measuring small direct voltages and currents.

Professor van der Ziel's treatment is intended to show how the solutions of most noise problems can be reduced to an analysis of simple networks. He provides an authoritative survey of the tremendous advances made in our understanding of the sources of essential and non-essential noise in electronic devices, and builds up a remarkably comprehensive picture of the present position. As a source of reference covering all the aspects of noise that concern the radio engineer this is a work of major importance.

LEGAL KNOWLEDGE SAVES TIME AND MONEY

Law and the Engineer: The Law of Contract and Negligence as Affecting Engineers. By CHRISTOPHER F. MAYSON. *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.2.* (63*s.*)

The engineer might well say that the law has spread its tentacles throughout his profession. Equally, the lawyer can contend that at last industry as a whole is conducted with safety, thanks to the wise imposition of safety regulations. Both statements are substantially true; as the lawyer with an industrial practice has found he needs a knowledge of engineering, so also must the engineer have some knowledge of the law. An engineer in a factory must know the Factories Acts; in building, the Building Regulations; if a consultant, then the legal implications of the various standard forms of contract, and so on throughout the different facets of the engineering profession.

Until this volume was published there was no book that would give the engineer the legal knowledge he requires in his everyday work. This book attempts, with a high degree of success, to state in easily understandable English those principles of law which are an essential part of an engineer's equipment.

It is only if one knows the background of the English legal system that one can start to understand the law. Many, for instance, wonder how the House of Lords can appear to make law without the concurrence of the lower house; the book explains that type of anomaly. Likewise why the judicial type of ignorance displayed by the question, "What is a nut and bolt?" is not as absurd as it sounds. But it is the law of contract that has probably more influence on industry than any other branch of the law, for it is by making agreements that industry gathers its raw materials and disposes of its products. It is not, therefore, surprising to find in a work of this nature that contract occupies the major part.

Persons in responsible positions should realise the legal consequences of their actions, yet from the cases cited it is clear that many do not. For example, if a manufacturer orders machinery for his plant, he should know when the machinery becomes his, so that the necessary insurances can be effected. Does he own it when it is finished and ready for dispatch, or when it leaves the seller's works, or when it is delivered, or installed, or when it is paid for? Ownership creates many legal obligations and therefore it is essential that one should know at least when one comes into possession of an object.

Law and the Engineer covers all these points and it is therefore a valuable compendium. By reading it the engineer executive may save thousands of pounds for his company. Suppose a machine fails owing to the breakdown of a mechanism and that the offending mechanism must be sent to the makers for repair. Meanwhile, with the machine idle a valuable contract cannot be completed. The engineer in charge rings up a firm of carriers and tells them to take the broken mechanism to the makers; they agree to do so next day. Something goes wrong, however, and the mechanism is left lying around for several days in the carriers' yard. The valuable contract is not completed on time owing to the machine being idle, and the firm lose their profit and have to pay damages for not completing the work by the stipulated day. Can they recover these damages and lost profits from the carriers? No, because the engineer in charge did not tell the carriers the circumstances which made it essential for the faulty mechanism to be delivered to the makers promptly. If he had known his law he would have saved his firm the loss.

In these days of actions for personal injuries by workmen, it is essential to know the numerous safety regulations. It is not practicable to have teams of lawyers walking round machines, climbing ladders, and poking their rolled umbrellas through guards to see that the regulations are being complied with. Those in charge must know the regulations themselves, they must be able to tell at a glance whether a machine is properly fenced. Only by knowing the law and applying it can the thousands of claims on employers made each year by injured workmen be avoided.

Litigation is expensive, not only in money for the lawyers (which is usually a matter for the insurance companies) but in time, for a company is certainly not profiting when they have some of their key men waiting about the Law Courts for a case to be heard. In a recent case a company's superintendent of works flew from Newfoundland to give evidence, the Court rose for the Summer Vacation before he had been heard, so he had to fly back to Newfoundland and then return to England two months later when the case was continued.

The book is written by a barrister who is also an engineer, and he has an obvious understanding of the engineer's problems. There is a foreword by Lord Justice Denning, one of the most able judges on the Bench, who writes, "I expect that many an engineer can get along very well without knowing anything about the law; but I cannot help thinking that he would get along a good deal better if he had some knowledge of it."

The Engineering Outlook—2

MANPOWER IN ENGINEERING

WAGES CHASING PRODUCTIVITY

The picture presented in looking forward in the first month of 1956 is very similar to that seen in prospect exactly a year ago. There is a large wage claim from the engineering unions, a generally unsettled industrial climate and also the opportunities and attendant problems of the increase in automatic controls and nuclear fission in industry. There is the same chronic problem of reconciling the need for a large increase in engineering output from a labour force which grows at a tantalisingly slow pace. There is the same difficulty of coping with rising labour costs. There are in fact only two major differences between the prospect now and that of a year ago, namely the onset this year of the American boom and the effects at home of the credit squeeze.

The main lesson which this similarity of outlook holds for 1956 is that neither the opportunities nor the perplexities which seem about to overtake the engineering industry at the beginning of a year are necessarily those which will have to be encountered as the year unfolds. Throughout 1955 there was much discussion about automation, but except as a talking point the automatic factory did not make a big impact either on industrial production or on industrial relations. The time has still to come when it will become a critical issue. The Institution of Production Engineers have held a conference on the subject, and some shop stewards from the motor-vehicle industry have held an unofficial conference at Oxford about automation in their own industry, and issued a warning about redundancy. But the implications of automation both for output and labour relations are emerging rather more slowly than was popularly expected. Even the major wage award won by the A.E.U. last March has been absorbed, albeit with difficulty in many cases, and the brave words about rationalising the cumbersome wage rate structure in the industry have passed like water under a bridge. In the negotiations now taking place for a further wage increase, remarkably little has been heard about the willingness of the unions to tackle this problem of the wage structure.

HIGHER OUTPUT

It is not unlikely that the achievements in the deployment of manpower in 1956 will be of the less spectacular sort which occurred in 1955. There is no doubt that the big gains last year were a notable increase in the economy's capital formation involving a higher output of engineering goods, which was helped by an increase in the engineering labour force. This last favourable development was one which even the optimists would have hesitated to forecast for a year which was in fact to see the unemployment percentage for industry as a whole hover between 1·0 and 0·9. In this article last year we said that the critical issue for the engineering industry on the manpower side would be to get a large enough increase in productivity to enable the industry to carry the higher wage rates which were then imminent. In the event, these wage rates have been borne, with varying degrees of discomfort, to the accompaniment of a big increase in output and a large increase in the rate of gross capital formation by the country as a whole. The increase in productivity in 1955 was gained not by gestures by the trade unions on revision of the wage structure, nor by a tidy and massive expansion in the output of industrial equipment based on a growing appreciation of the advantages of automation, but on a hotch-potch of increased orthodox mechanisation, additional overtime, managerial improvisation and a bigger labour force. The facts behind this achievement can be seen from the following paragraphs.

During the year the engineering industry increased its manpower by a small but significant amount. It will be seen from the Table that there was hardly a category in which there was not an increase in labour recorded between September, 1954, and September, 1955, the latest date for which detailed figures are available. A feature of the increase has been the evenness of its spread over the engineering field. If the first category, covering metal manufacture, is excluded there was a fairly uniform increase of 5 to 5½ per cent. in the main engineering groups over the year under consideration, except for precision instruments where the increase was only 1½ per cent. Yet there was an increase of only 0·75 per cent. in the working population.

MACHINE TOOLS: HIGH PRODUCTIVITY

Within these engineering groups the largest increase in manpower was achieved by machine tools, wireless apparatus and wireless valves, and also by bolts, nuts and screws. In the case of machine tools a 10 per cent. increase in manpower was accompanied by about an 18 per cent. increase in output.

The spread of the increased labour force has been satisfactory too. It has been apparent for some time that the machine-tool and electronics industries were experiencing remarkable demand for their goods and these industries have in fact been able to attract rather more new labour than other engineering industries. At the other extreme, the metal manufacturing industries, especially the iron and steel industry, achieved very notable increases in output with only a small increase in their labour force. Indeed if the non-ferrous metals are excluded the iron and steel industry attracted remarkably little new manpower; the blast furnaces, which had a record year, actually employed fewer people in September, 1955, than in the same month of 1954.

Employment in the Metal Manufacturing and Engineering Industries of Great Britain (Thousands)

—	Sept., 1953	Sept., 1954	Sept., 1955
Metal Manufacture	550·7	556·4	572·8
Blast furnaces	21·8	21·4	21·3
Iron and steel melting, rolling, etc.	222·4	221·1	226·7
Iron foundries	124·8	123·9	126·3
Tinplate manufacture	13·9	14·0	14·2
Steel sheet manufacture	19·6	19·6	20·1
Iron and steel tubes (incl. melting and rolling in integrated works)	44·0	44·8	46·9
Non-ferrous metals, smelting, rolling, etc.	104·2	111·6	117·3
Engineering, Shipbuilding and Electrical Goods	1,917·5	1,991·7	2,097·3
Shipbuilding and ship repairing	208·5	202·4	209·4
Marine engineering	76·1	80·0	79·2
Agricultural machinery (excl. tractors)	38·9	39·1	43·4
Boilers and boiler-house plant	30·0	30·6	31·4
Machine tools	101·8	107·1	113·3
Stationary engines	26·1	27·0	27·9
Textile machinery and accessories	66·5	66·3	65·6
Ordnance and small arms	62·6	64·8	62·9
Constructional engineering	84·9	82·1	85·3
Other non-electrical engineering	618·1	638·5	667·4
Electrical machinery	174·1	179·4	190·2
Electric wires and cables	58·0	60·1	64·5
Telegraph and telephone apparatus	53·9	53·1	57·1
Wireless apparatus (excl. valves) and gramophones	112·1	127·7	146·4
Wireless valves and electric lamps	41·0	46·1	54·4
Batteries and accumulators	19·9	21·2	21·0
Other electrical goods	145·0	166·2	177·9
Vehicles	1,109·1	1,158·1	1,215·8
Manufacture of motor vehicles and bicycles	298·1	315·7	338·5
Motor repairers and garages	269·8	275·1	285·6
Manufacture and repair of aircraft	221·6	233·7	246·9
Manufacture of parts and accessories for motor vehicles and aircraft	147·4	159·8	173·8
Locomotive manufacture	83·1	81·9	80·1
Manufacture and repair of railway carriages and wagons and trams	81·0	83·7	82·8
Carts, perambulators, etc.	8·1	8·2	8·1
Metal Goods not elsewhere specified	486·2	501·5	522·5
Tools and cutlery	44·9	46·9	49·0
Bolts, nuts, screws, rivets, nails, etc.	39·3	41·2	44·7
Iron and steel forgings, not elsewhere specified	38·6	39·0	40·5
Wire and wire manufacture	37·9	37·4	39·3
Hollow-ware	60·8	60·3	61·4
Brass manufacture	45·7	49·1	51·3
Metal industries not elsewhere specified	219·0	227·6	236·3
Precision Instruments, Jewellery, etc.	135·6	139·6	144·1
Scientific, surgical and photographic instruments, etc.	85·7	86·9	89·6
Manufacture and repair of watches and clocks	16·5	16·5	17·5
Jewellery, plate and refining of precious metals	24·9	27·8	28·0
Musical instruments	8·5	8·4	9·0

While the labour force increased overall by about 4 per cent. (if the numbers employed in metal manufacture are added to those in engineering) the increase in output over the period was about 9 per cent. This means that the increase in productivity was of the order of 4 per cent., although it varied quite considerably as between one section of the engineering industry and another. Nevertheless, the overall impression is that the increase in production owed about as much to higher productivity as to an increase in the labour force. Even in sections of the industries which expanded their output at more than the average—machine tools is a case in point which has already been quoted—the increase in productivity was accompanied by an increase in manpower that was roughly equal.

It was said earlier that the major gain in 1955 was the increase in capital investment helped by the increase in the labour force and productivity. In this article of the series last year we emphasised that the prospect for a big increase in engineering output that would enable the industry to absorb the wage increase which was agreed in March, 1955, would depend on a major advance in the gross capital formation by the community as a whole. This increase in fact took place. Taking the figures so far available for the gross capital formation achieved last year and in 1954, and basing them on 1948 prices, the gross domestic fixed capital formation of the country as a whole in 1955 was about £2,034 million, compared with £1,826 million in 1954 and £1,741 million in 1953. In other words, whereas the formation of gross domestic fixed capital increased by 5 per cent. in 1954 it probably increased by as much as 11 per cent. in 1955. There was also a notable expansion in engineering exports during the year, so the wage concession of last March was to some extent absorbed by a big increase in turnover at home and abroad, aided until the closing months of the year by the Government's economic policy. Until the autumn Budget it could not be said that the credit restriction policy was directly aimed at or seriously affected the heavy-engineering industry.

OFFSETTING INCREASED COSTS

It has been said that the increase in wages was to some extent offset by this increase in capital formation. It is doubtful, however, if all engineering concerns could offset all the increase in wages either by higher prices or the economies of large-scale production and it is certain that many companies found higher wages, together with higher raw material prices, a serious embarrassment as the year went on. Of recent months evidence has been accumulating that many companies have enjoyed higher turnover in their latest trading year but only at a reduced profit per unit of output. Towards this reduction, higher wages have made at least some contribution.

To-day, at the same period of 1956 as in 1955, the industry faces a demand for a large increase in wages (this time put at 15 per cent.) based on the assertion by the unions that the industry is increasingly prosperous, that productivity is rising and that so also is the cost of living. It is true that prosperity is increasing but marginal output is becoming less profitable and the continuing pressure of wages may yet have serious repercussions on exports. Productivity in the industry has increased over the last year

probably no more than by about 4½ per cent. while the cost of living has gone up by 5½ per cent. between March and November. These figures suggest that a settlement in the region of 10 per cent. may be feasible if the employers are prepared to accept the point that wages should increase proportionately to productivity and the cost of living. The figure of 15 per cent. can be regarded only as an initial bargaining position by the trade unions.

Even a notional figure of 10 per cent. begs many questions. It would appear that it may be absorbed by the industry without acute embarrassment (the emphasis is on the word "acute") only if gross national capital formation (including engineering output), employment in the engineering industry, and the export drive continue to expand at the same rate as in 1955. Is this likely to happen? There is every indication that the credit squeeze will prevent gross capital formation and engineering output increasing at the same rate as last year. At a guess, the rate of increase might possibly be somewhere between that for 1954 and that for 1955. Engineering output, especially at the lighter end of the trade, is likely to feel the impact of higher purchase tax as well as credit restriction at least until such concessions as the April Budget may offer can come into force by the early summer. On the other hand, there is a good possibility that recruitment will continue to go on at its recent gradual rate, especially if wages are high and the credit squeeze achieves its object. So far as the home market is concerned, on balance the possibility of the industry absorbing a substantial wage increase with no more embarrassment than in 1955 is somewhat reduced. This somewhat pessimistic conclusion is reinforced by the fact that raw material prices are likely to remain very firm, a prospect which was discussed in some detail in last week's article.

15 PER CENT. WAGE CLAIM

In the export market the prospect is frankly disturbing. A glance at recent figures of wage increases in this country compared with those abroad (and the trend of wages in general is not out of line to any serious extent with the trend of engineering wages in particular) shows that the apprehension expressed by Sir Percy Mills in January when the unions formally made their 15 per cent. claim was not a mere bargaining gesture. If the position in the first half of 1955 (which covers the introduction of the last increase in engineering wages) is compared with that in 1952 it will be found that the percentage increase in hourly earnings for manufacturing industry as a whole was greater for the United Kingdom than any other major industrial country in the world. We have to go back to 1950 before the rate of increase in certain other countries exceeded that for the United Kingdom. Even in the five years 1950 to 1955 only Sweden, France and Japan exceeded the percentage increase of the United Kingdom, and Japan was a special case. The hourly earnings in this country have therefore been increasing more quickly in the last three years than any other country, and in the last five years they have been exceeded only by three countries. Taking industrial production over the last three years, this country has increased its average monthly rate less than Germany, Italy or Japan. Over the last five years Britain's performance is inferior to Germany, France, Italy, Belgium and Japan and ranks about equal to that of the United States.

This is not an impressive performance for a country which is trying to increase the volume and value of its exports. It is quite clear from these figures that hourly earnings in this country have gone up more quickly than in countries abroad which are our severest competitors, while industrial production has not increased rapidly enough to absorb the higher earnings. There is therefore a real danger that in 1956 our exports will be seriously embarrassed by high wages as well as raw-material costs.

What are the chances that this rather pessimistic conclusion may not work out in practice? It is possible that the credit squeeze may achieve its effect in time for the Budget to bring a relaxation of this squeeze and offer some encouragement to increase orders for equipment from those sections of the engineering industry which are bearing the brunt of the present restrictive policy. If this should happen it would be possible to think again in terms of an expanding economy, an encouraging rate of increase of productivity and the likelihood of further strides being made towards automation It is also possible that strikes may be less of an obstacle to increasing output in 1956 than in 1955. In this connection, however, it is necessary to bear in mind two things. First, the unions in general are adopting a more militant policy in wage negotiations than they were a year ago, and it is highly likely that labour organised by the T.G.W.U. (and many engineering concerns have this union to deal with as well as the A.E.U.) will be less accommodating in reaching agreement on wage demands than they were in 1955.

It is possible, however, that wages may begin to rise more quickly abroad, notably in Germany, than they have done in the recent past. The German economy is very vulnerable in some respects to higher wages, for capital investment, although impressive, has had large arrears to make up after the dismantling period came to an end, and recovery has owed much to an efficient, expanding labour force which is now fully employed. Here is the nub of the situation for 1956. Wage costs will go up in this country. Time alone can answer the following two critical questions. First, can they be spread over a higher output? Second, will wage costs abroad begin to catch up with those in this country? The answer could be "Yes," but at the beginning of the year it has to be given with more hope than conviction.

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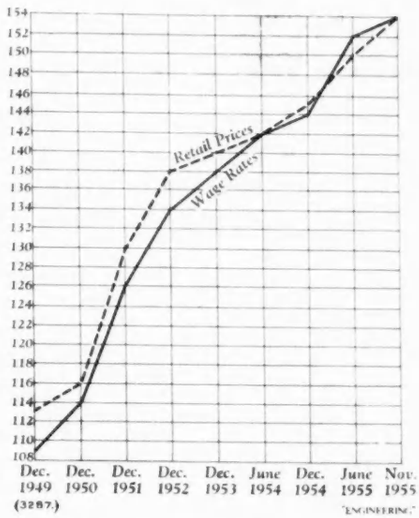


Relative movements in retail prices and wage rates since 1949. (Index: June, 1947 = 100.)

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Centreless Grinding. CINCINNATI MILLING MACHINES, LTD., Woodlands Farm-road, Tyburn, Birmingham, 24. No. 2 centreless grinder. A new machine more than 1,000 lb. heavier than its predecessor and incorporating many new features. Capacity: with standard work-rest $\frac{1}{16}$ in. to 3 in. diameter, with low throughfeed work-rest 2 in. to 4¾ in. diameter. The machine incorporates a ball-bearing mounted lower slide, infinitely variable speed drive to the regulating wheel, pressure lubrication of the regulating wheel spindle bearings, and stabilised in-feed screw. A wide range of extra equipment is available, including automatic balancing of the grinding wheel. Illustrated brochure.

Heavy Civil Engineering Plant. SOUTHWEST WELDING AND MANUFACTURING CO., Alhambra, California. Ripper: model RXH-3, weighing 25,000 lb. and designed to give standard penetration depths of 36 in., 42 in. and 48 in.; additional centre claw available to cut to depths of 60 in. Sheepsfoot rollers: one or two drum models; drums of 5 ft. diameter by 5 ft. long and weighing about 14,000 lb. when filled with water. Compaction roller: five models with rated capacities of 10 to 100 tons, built around Caterpillar tractors. Illustrated leaflets.

Thread Grinding. COVENTRY GAUGE AND TOOL CO., LTD., Coventry. "Matrix" plain thread grinding machine in two sizes: No. 37 for work up to 14 in. diameter by 20 in. long, and No. 47 for work of the same diameter but up to 42 in. long. Both machines produce single or multi-start parallel threads of any desired form with any desired pitch from 0·025 in. to a lead of 12 in. Extra equipment for internal thread grinding and a wide range of other purposes is available. Illustrated brochure.

Repeating Coil for Audio Cables and Repeater Systems. STANDARD TELEPHONES AND CABLES, LTD., Transmission Division, North Woolwich, London, E.16. Typical examples of the wide range of repeating coils manufactured for use in the audio range. Tables of sizes, weights and electrical characteristics. Summaries of principal features. Illustrated pamphlet. C/2010 Ed. 2.

Electric Soldering Iron. THE ACRU ELECTRIC TOOL MFG. CO. LTD., Chapel-street, Stockport-road, Levenshulme, Manchester 19. Extra heavy duty electric soldering iron weighing 8 lb. Power consumption 450 watts. Maximum heat reached in 5 minutes. Three interchangeable copper bits. Aluminium can be soldered when using special A1 solder. Illustrated leaflet.

Compressed-Air Pumps and Valves. CHARLES S. MADAN & CO. LTD., Vortex Works, Altrincham. The "Airhydropump" air-operated hydraulic compressors, single and double acting giving hydraulic pressures up to 27,200 lb. per sq. in.; also Vortex and Ghurkha pumps, control valves up to 50,000 lb. per sq. in., and special testing equipment. Illustrated catalogue.

Synchronous Process Timer. LONDEX, LTD., Anerley Works, 207 Anerley-road, London, S.E.20. New process timer for panel mounting with adjustable time setting and automatic re-setting. Synchronous driving motor. Control of any process either directly or by light or other signals. Illustrated list No. 170.

Self-Priming Centrifugal Pumps. GOODENOUGH PUMPS LTD., 70-72 London-road, Twickenham, Middlesex. Automatic self-priming centrifugal pumps with outputs up to 75,000 galls. per hour. Skid or trailer mounted with petrol or Diesel engines. Illustrated catalogue.

Capstan Lathe. MURAD DEVELOPMENTS, LTD., Stocklake, Aylesbury, Buckinghamshire. 6¾ in. centres capstan lathe with 16 spindle speeds in forward and reverse, 6 automatic feeds to the turret, and 6 automatic feeds, both longitudinal and transverse, to the cross slide. Illustrated leaflet.

Electricity for Spinning Mills. BRITISH THOMSON-HOUSTON CO., LTD., Rugby. The use of electric drives in the cotton-spinning mills; equipment required, planning and problems encountered. Booklet by Mr. S. Birchall, entitled "Cotton Spinning Mills: Conversion from Steam to Electric Drive."

Welding Equipment. QUASI-ARC LTD., Bilston, Staffordshire. Welding sets, generators, transformers and ancillary equipment; electrodes, shields, positioners and all equipment for manual or automatic welding. Illustrated descriptive booklet, TC 845/9.

Verniers and Micrometers. BROOKS AND WALKER LTD. 47 Great Eastern-street, London, E.C.2. "Ritefeel" verniers, calipers, height and depth gauges, up to 72 in. capacity; gear-tooth calipers, and inside and stick micrometers up to 50 ft. 7 in. capacity. Illustrated catalogue.

Engineers' Stethoscope. CAPAC CO. LTD., 2 Ullswater-road, London, S.W.13. Bin and Mon Aural stethoscopes for noise and vibration detection. Can also be used for noise comparison and to test surface finish. Leaflets.

Portable Metal Saw. EDWARD G. HERBERT LTD. Atlas Works, Levenshulme, Manchester 19. "Rapidor" portable saws, hand or power-operated, for cutting bull-head or flat-bottomed rail. Illustrated leaflet.

WATER-COOLED REACTORS

DESIGNING POWER PLANTS TO USE BY-PRODUCT PLUTONIUM

When by-product plutonium becomes available in quantity from the early nuclear reactors, it will be desirable to have other reactors capable of using it as fuel. Such reactors will be designed to burn plutonium in conjunction with natural or depleted uranium as efficiently as possible, and among the more promising thermal reactor systems which could be developed for this purpose are the sodium-cooled graphite reactor and the pressurised-water moderated reactor. In a paper entitled "The Pressurised Water Reactor as a Source of Heat for Steam Power Plants," presented at a general meeting of the Institution of Mechanical Engineers on December 14, 1955, by J. M. Kay, M.A., Ph.D., A.M.I.Mech.E., and F. J. Hutchinson, M.Eng., Member of Council, I.Mech.E., M.I.E.E., the pressurised-water reactor was examined from the power-plant engineer's point of view; and various ways in which it could be employed as a source of heat for steam power stations were discussed. Boiling-water and flash-steam reactors were also considered. The meeting was held in conjunction with the British Nuclear Energy Conference in the Great Hall of the Institution of Civil Engineers. An abridged version of the paper is given below.*

PRESSURISED-WATER SYSTEM

The description "pressurised-water reactor" will be taken to include both light-water and heavy-water moderated reactors employing a pressurised-water cooling system. The general engineering features

* Both of Kennedy and Donkin, consulting engineers.

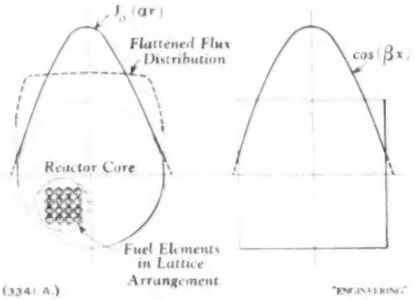


Fig. 1 Heat release in a reactor core. In the case of a thermal reactor with a cylindrical core and reflector, the heat release follows a Bessel function distribution with radius, and a cosine distribution with axial distance.

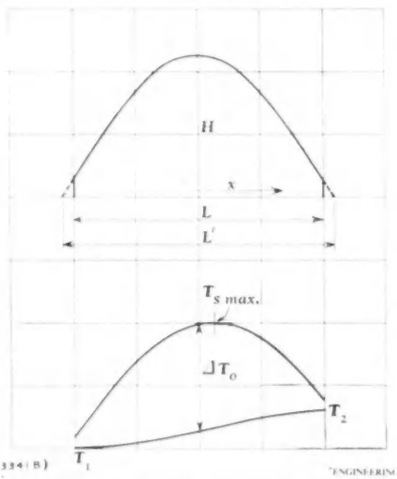


Fig. 2 Heat release and temperature distribution in a channel. It is desirable to avoid large peaks in heat release at the core centre (see Fig. 1), and this is effected by "flattening." As a result, calculations of heat transfer may be confined to a single channel.

would be similar in both cases. A heavy-water moderated reactor, however, is capable of using natural uranium provided a calandria type of construction is used, so that most of the moderator can be maintained at high density. In addition, because of the rather open lattice arrangement required, it involves a rather larger diameter of core. A light-water moderated reactor on the other hand must be fuelled either with enriched uranium or with a mixture of uranium and plutonium, and the ratio of moderator volume to fuel volume is much smaller than with the heavy-water reactor.

The core of a pressurised-water reactor will consist of a cylindrical assembly of fuel elements arranged in lattice formation and housed inside a pressure vessel. Each fuel element will normally be located inside a coolant channel or duct, and water will be circulated at a fairly high velocity to secure the required rate of heat removal. The moderator and coolant water must normally be pressurised to prevent the occurrence of boiling inside the core.

There is now sufficient published information on neutron diffusion theory and the properties of uranium to enable engineering calculations to be made regarding the sizes of certain types of nuclear reactor and the distribution of heat release. Consider the case of a thermal reactor with a cylindrical core and reflector. The heat release per unit volume of core will be given by an equation of the form

$$Q = Q_{max.} J_0(\alpha r) \cos(\beta x) \quad . \quad . \quad (1)$$

that is, the heat release follows a Bessel function distribution with radius, and a cosine distribution with axial distance as indicated in Fig. 1.

NEUTRON FLUX AND HEAT RELEASE

In many reactor designs the radial distribution of the neutron flux and heat release is deliberately altered by "flattening." This can be achieved by using two different types of fuel element with different degrees of enrichment; by introducing neutron-absorbing material in the central region of the core; or by other devices. From an engineering point of view it is obviously desirable to avoid a large peak in the heat release at the centre of the core. It will therefore be reasonable to confine the investigation of the heat transfer between fuel element and coolant to a single channel, and to assume a channel rating equal to the radial average for the whole core.

The axial distribution of neutron flux and heat release may also be subject to distortion if control rods are employed which operate by axial movement into and out of the core. However, for the purposes of a preliminary calculation it will be sufficient to take the normal cosine distribution; that is the heat release per unit length for a single channel will be given by

$$H = H_0 \cos \frac{\pi x}{L'} \quad . \quad . \quad (2)$$

where H_0 is the maximum rate of heat release per unit length at the centre of the channel; x is the axial distance measured from the centre; and L' is the extrapolated length of the core.

For heat transfer from the surface of a fuel element to the coolant, the heat flux q will be given by

$$q = \frac{H}{b} = h(T_s - T)$$

and hence

$$T_s - T = \frac{H_0}{b\,h} \cos \frac{\pi x}{L'} \quad . \quad . \quad (3)$$

where T_s is the surface temperature of the element; T is the coolant temperature; h is the heat-transfer factor; and b is the effective perimeter of the element.

The temperature rise of the coolant in flowing along a channel is given by

$$m\,c_p\,dT = H\,dx$$

or

$$\frac{dT}{dx} = \frac{H_0}{m\,c_p} \cos \frac{\pi x}{L'} \quad . \quad . \quad (4)$$

and hence

$$T_2 - T_1 = \frac{H_0}{m\,c_p} \cdot \frac{2L'}{\pi} \sin \frac{\pi L}{2L'}, \quad . \quad (5)$$

where T_1 is the inlet coolant temperature; T_2 is the outlet coolant temperature; m is the mass flow of coolant in the channel; and c_p is the specific heat of the coolant. The resulting temperature distribution along the surface of the fuel element is shown for a typical case in Fig. 2.

If boiling of the water inside the core is to be prevented, the maximum surface temperature of a fuel element must not be allowed to rise above the saturation temperature at the reactor pressure. This limitation will fix the permissible temperature levels throughout the reactor.

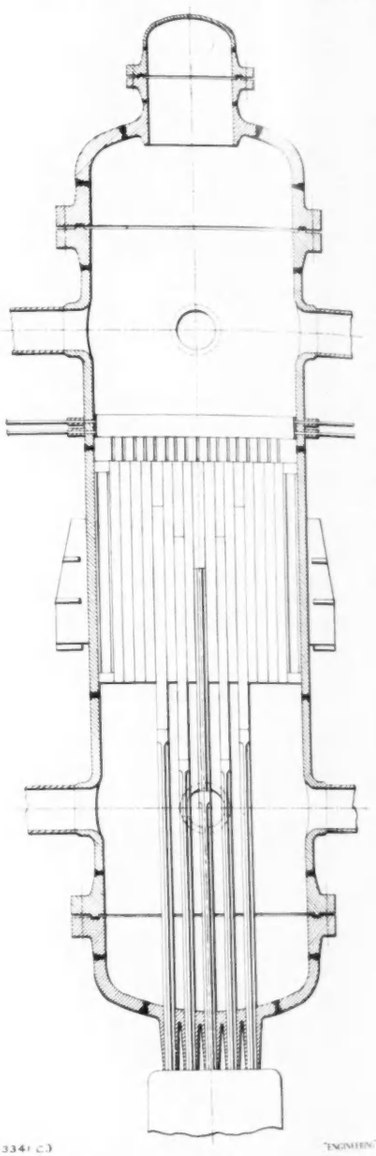


Fig. 3 Pressure vessel for pressurised-water reactor. In systems using water as coolant and moderator there are two main approaches: in one the water is permitted to boil; in the other it is maintained under pressure to prevent boiling, thus eliminating steam voids in the core and consequent fluctuation in moderator action. The vessel shown is 9 ft. in internal diameter and designed for a working pressure of 1,500 lb. per sq. in. (Babcock and Wilcox).

The difference between the maximum surface temperature and the coolant inlet temperature T_1 is of particular interest, and this is given conveniently by Ginns's equation which can be derived from equations (3) and (4).

$$T_{s\,max.} - T_1 = \tfrac{1}{2}(T_2 - T_1) + \sqrt{\Delta T_0^2 + \left[\frac{\tfrac{1}{2}(T_2 - T_1)}{\sin \frac{\pi L}{2L'}}\right]^2} \quad . \quad . \quad (6)$$

where ΔT_0 is the value of $(T_s - T)$ at $x = 0$; that is $\Delta T_0 = \frac{H_0}{b\,h}$.

It is convenient to start with the case of a fuel element of circular cross-section surrounded by an annular passage for the coolant. The nuclear calculations for the core are usually based on an equivalent lattice element or unit cell of this type, even though a

different shape for the fuel element may ultimately be chosen, and heat transfer calculation can then be made.

PRESSURE VESSEL

The core diameter of a light-water reactor of the type under consideration might be between 6 and 8 ft., depending on the degree of enrichment and quantity of the fuel to be used. The core diameter of a heavy-water reactor, on the other hand, would be larger than this owing to the necessarily greater moderator : uranium ratio required and the correspondingly more open lattice.

For a light-water reactor, if allowance is made for adequate thickness of reflector surrounding the active core, a pressure vessel of 9 or 10 ft. diameter would be required. The absolute temperature level in the reactor will be fixed by the permissible reactor pressure, and it is therefore necessary to determine the upper practical limit. Table I gives the wall thickness required for a fusion welded mild-steel pressure vessel of 10 ft. internal diameter.

The 1,500 lb. per square inch case probably represents a reasonable upper limit, and should not involve going far outside the range of normal welding techniques or existing manufacturing capacity.

TABLE I.—*Wall Thickness and Working Pressure*

Reactor working pressure, lb. per sq. in.	1,000	1,500	2,000
Wall thickness, in.	5	7½	10

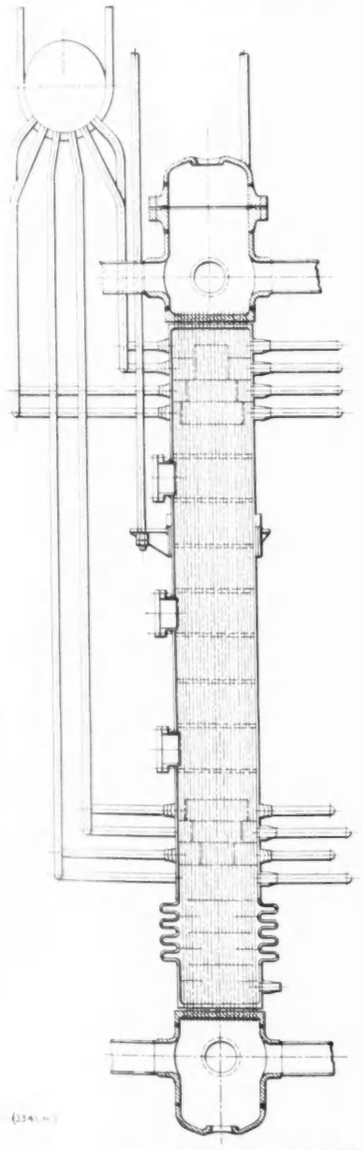


Fig. 4 Typical steam-raising plant. Pressurised water from the reactor is passed to an external heat exchanger, shown here, in which steam is generated (Babcock and Wilcox).

The most difficult part of the pressure-vessel design will be the method of end closure. It would be desirable to have a removable end or top cover which could be opened up for major refuelling operations; protection from radiation under these conditions would be provided by flooding the reactor with water to a level of some 6 or 8 ft. above the top of the core. The design of a satisfactory flanged and bolted joint for the diameter and pressure envisaged, however, presents a serious problem.

The leading proportions of a typical pressure vessel of 9 ft. internal diameter, designed for a working pressure of 1,500 lb. per square inch, are shown in Fig. 3 (Babcock and Wilcox, Limited). If 1,500 lb. per square inch is taken as the limiting reactor pressure, the corresponding saturation temperature will be 596 deg. F. and this will fix the permissible temperature levels throughout the plant. In the limiting case, with local nucleate boiling at the hottest point on the surface of the fuel element, the permissible value of $T_{s\,max.}$ would therefore be equal to the saturation temperature, 596 deg. F. Some provision, however, must be made for departure from design conditions, and in the analysis below of the steam cycle an additional 20 deg. F. will be allowed; that is, the maximum surface fuel-element temperature will be taken as 576 deg. F.

There are various possible methods for maintaining and controlling the pressure in the reactor-vessel and coolant circuit. One arrangement involves the use of a special pressurising tank or steam dome, in which the water is heated electrically to the boiling point corresponding to the reactor pressure.

PRIMARY COOLANT CIRCUIT

It has been noted that with fuel elements of approximately ½ in. equivalent diameter, the temperature difference ($T_{s\,max.} - T_1$) could be limited to about 100 deg. F. at a heat rating of 20 million B.Th.U. per hour per cubic foot without employing excessive water velocities. The temperature rise $T_2 - T_1$ of the coolant in a channel will depend on the heat rating for the channel and the mass flow of water. For a given heat rating for the fuel, and for a given water velocity, the coolant temperature rise will therefore depend on the geometry of the channel. In the following calculation a value of 36 deg. F. will be taken as a typical figure. For a 500 MW reactor this would imply a total mass flow of water of approximately 12,000 lb. per second or 90,000 gallons per minute at 1,500 lb. per square inch.

With these values for the temperature differences, and a maximum fuel-element surface temperature of 576 deg. F., some typical figures for the temperatures in the reactor and coolant circuit can be obtained, and these are given in Table II.

TABLE II.—*Typical Figures for the Temperatures in the Reactor and Coolant Circuit.*

—	Temperature, deg. F.
Maximum at uranium centre	786
Maximum at fuel-element surface	576
Coolant outlet	512
Coolant inlet	476

For the external heat exchanger in this case a steam pressure of 450 lb. per square inch and saturation temperature of 456 deg. F. may be assumed. A suitable design for an external heat exchanger is shown in Fig. 4 (Babcock and Wilcox, Limited).

The drawing represents a shell-and-tube heat exchanger arranged as a natural circulation unit. Feed water enters the shell at the bottom and after passing through a feed preheating section mixes with the boiler circulation water, which is returned from the boiler drum. The mixture of steam and water leaves the heat exchanger at the top of the shell and passes to the boiler drum. High-pressure water from the reactor enters the header at the top of the unit and passes downwards inside the tubes of the heat exchanger, returning to the reactor by way of the header at the bottom. In view of the high pressure in the primary coolant circuit, and to avoid any danger of leakage, it would be desirable to employ a glandless pump with enclosed motor drive, such as that shown in Fig. 5 (Hayward Tyler and Company, Limited; see also ENGINEERING, vol. 180, page 433 1955.)

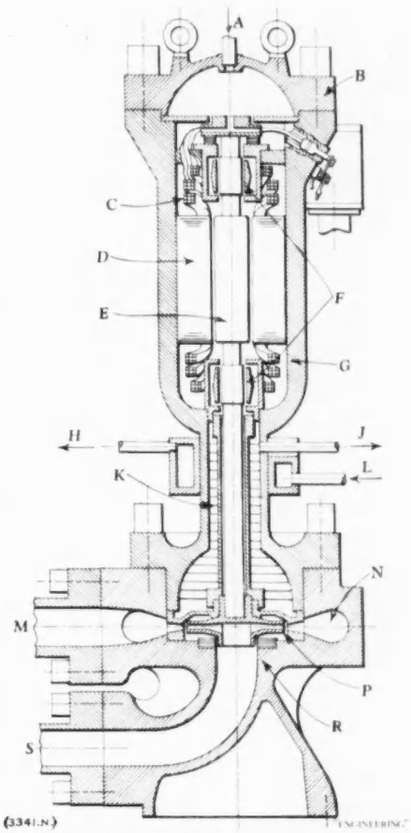


Fig. 5 Glandless circulating pump for pressurised primary coolant circuit (Hayward Tyler).

A. High-pressure circulation (in).
B. Pressure cover.
C. Stator windings.
D. Stator laminations.
E. Rotor.
F. Tilting-pad journal bearings.
G. Pressure shell.
H. Low-pressure cooling water from jacket.
J. High-pressure circulation (out).
K. Heat baffles.
L. Low-pressure cooling water to jacket.
M. Discharge.
N. Volute.
P. Impeller.
R. Pump case.
S. Suction.

FIVE STEAM CYCLES COMPARED

Thus with a reactor pressure of 1,500 lb. per square inch, saturated steam can be generated under practical conditions at a maximum pressure of about 450 lb. per square inch, and the next question is the choice of steam cycle and the design of the external plant. In the following comparison a number of different arrangements are analysed on the assumption that steam is generated at a normal working pressure of 420 lb. per square inch. These schemes are shown diagrammatically in Fig. 6. Fig. 6 (*a*) represents a cycle with saturated steam and water separation; (*b*) with saturated steam and intermediate reheat; (*c*) with saturated steam and live steam reheat; (*d*) with superheat from the reactor and lowered

TABLE III.—COMPARISON OF STEAM CYCLES.

—	Cycle (*a*) Water extraction	(*b*) High-pressure water reheater	(*c*) Live-steam reheater	(*d*) Low-pressure superheated steam	(*e*) Separately superheated steam
Turbine stop-valve pressure, lb. per sq. in. abs.	420	420	420	210	380
Turbine stop-valve temperature, deg. F.	450	450	450	450	900
Reheater inlet pressure, lb. per sq. in. abs.	—	100	100	—	—
Reheat temperature, deg. F.	—	450	400	—	—
Back pressure, lb. per sq. in. abs.	0·75	0·75	0·75	0·75	0·75
Final feed temperature, deg. F.	315	315	315	270	315
Turbo-generator efficiency, per cent.	27·8	27·8	27·3	24·3	32·3
Steam rate to turbine, lb. per kW.-hr.	13·28	11·65	11·84	13·9	9·04
Electrical output, MW	139·0	139·0	136·5	123·0	213
Steam to turbine, lb. per hr.	1,850,000	1,620,000	1,620,000	1,705,000	1,850,000
Steam to condenser, lb. per hr.	1,140,000	1,140,000	1,140,000	1,188,000	1 368,000
Exhaust area, sq. ft.	139	139	139	145	167

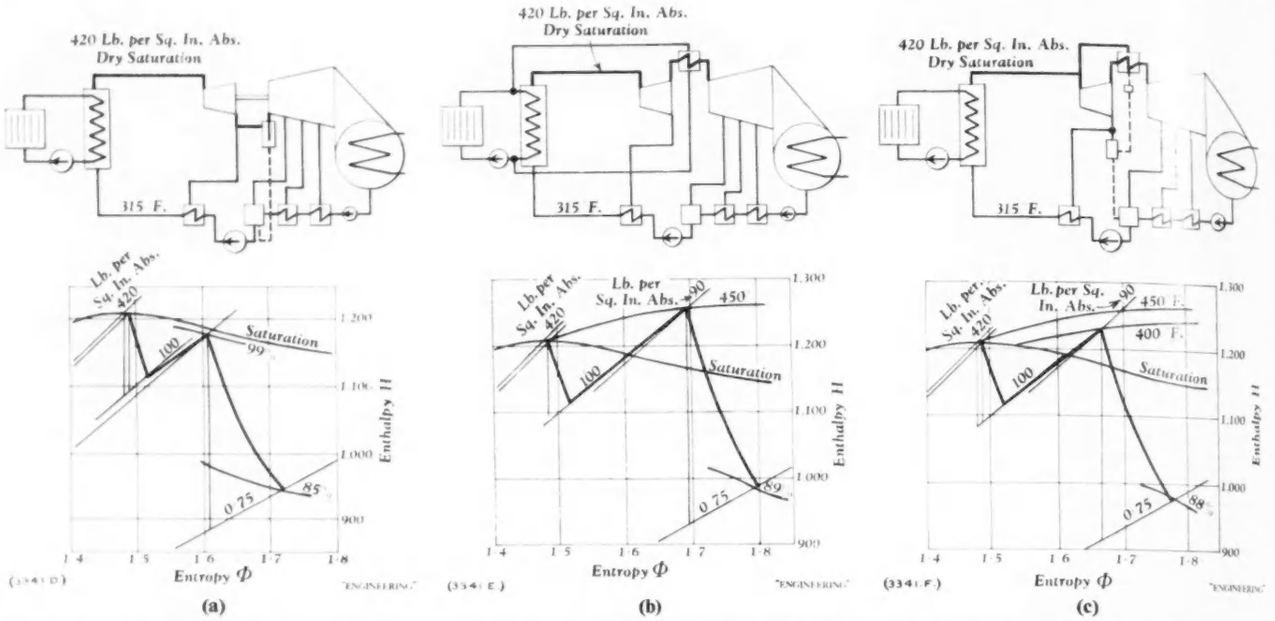


Fig. 6 Given a reactor pressure of 1,500 lb. per sq. in. saturated steam can be generated at about 450 lb. per sq. in., and a number of different steam cycles are possible. Those shown are based on the assumption that steam is generated at a working pressure of 420 lb. per sq. in.: (a) saturated steam with water separation; (b) saturated steam with intermediate reheat; (c) saturated steam with live steam reheat. (See Table III.)

boiler pressure; and (*e*) with external superheating from a combustion source.

The cycle efficiencies have been calculated using the following assumptions: in each case the back pressure has been taken as 0·75 lb. per square inch, and the leaving losses at 20 B.Th.U. per lb. flow through the last stage; the turbo-generator mechanical and electrical losses have been taken as 3 per cent. These assumptions are arbitrary and have been made for comparative purposes only.

A summary of the results is given in Table III. Owing to the relatively low initial temperatures and moderate heat drops the specific output of all the cycles is low if viewed in the light of modern high-temperature steam-plant practice. Even the least efficient cycles, however, can produce over 120 MW of electrical power from 500 MW of reactor heat. While the size of turbo-generator required for such plant is within the normal range of existing designs, some problems arise in connection with the low-pressure end of the turbine, which would not be encountered in a high-pressure machine of equal output. A triple exhaust arrangement is to be used on the first 200 MW. high-pressure machines running at 3,000 r.p.m. now on order from British companies.

The water extraction or reheat cycles shown in Table III. might just be covered by using a turbine having a similar frame. The other two cycles, particularly the 213 MW separately superheated cycle, would require four such exhausts if developed using a single machine of 3,000 r.p.m. By using a turbine of speed 1,500 r.p.m., however, an exhaust area of at least 75 sq. ft. and possibly as much as 100 sq. ft. could be accommodated. The 213 MW separately superheated cycle could therefore be developed using a single-shaft machine running at a speed of 1,500 r.p.m. and with a double exhaust. Alternatively, there should be no difficulty in building two machines running at 3,000 r.p.m. of approximately 100 MW each, two such machines being associated with a single 500 MW reactor.

If the separately superheated cycle is compared with the unsuperheated water-extraction cycle it will be seen that an additional electrical output of 74 MW is obtained. The combustion heat required for superheating the steam, if a figure of 88 per cent. combustion efficiency is assumed, would be 163·5 MW. The overall efficiency of the combustion end of the cycle is therefore 45·2 per cent. The two cases are set out for comparison in Table IV, where 500 MW reactor heat is considered in each instance.

TABLE IV.—*Comparison of Separately Superheated and Unsuperheated Water-Extraction Cycles.*

—	Water extraction cycle	Separately superheated cycle
Reactor heat, MW	500	500
Combustion heat, MW	—	163·2
Electrical output, per cent.	139·0	213
Overall efficiency, per cent.	27·8	32·3
Efficiency of utilisation of combustion heat, per cent.	—	45·2

If a coal-fired or oil-fired superheater is used it would be possible to provide some of the feed heating from the combustion heat. It will generally be found preferable, however, to make use of regenerative feed-heating as shown in Fig. 6(*e*) and to provide a large air preheater at the exhaust end of the combustion plant.

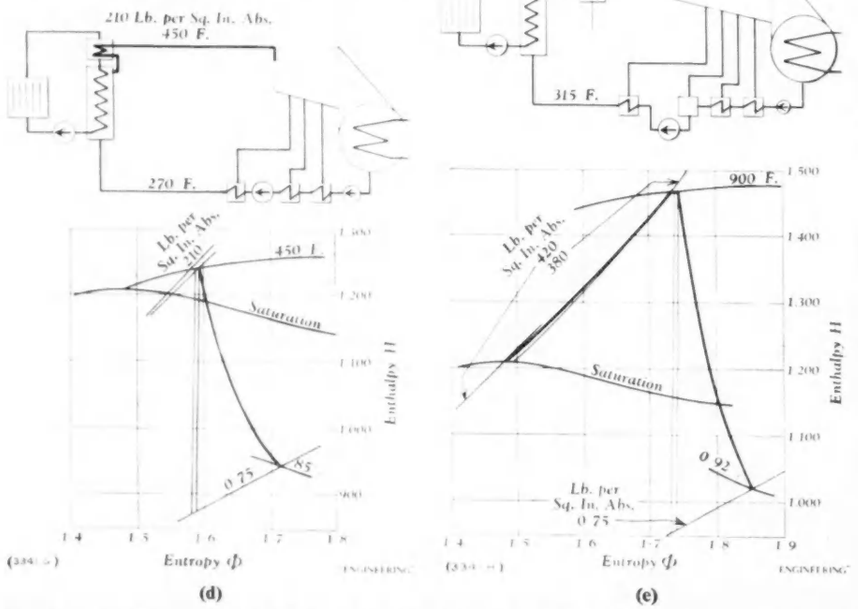


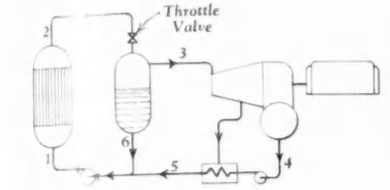
Fig. 6 (cont.) Even the least efficient cycles can produce over 120 MW of electrical power from 500 MW of reactor heat and the separately superheated cycle can give as much as 213 MW; (d) superheat from the reactor with lowered boiler pressure; (e) external superheating from a combustion source.

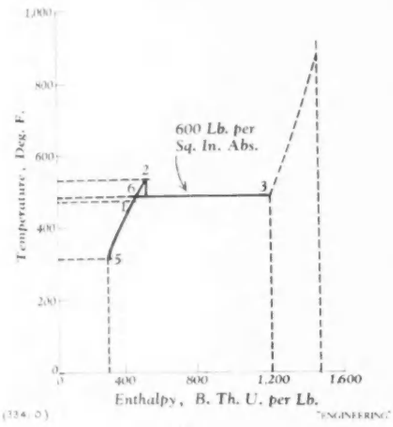
SEPARATE SUPERHEATER

In considering the use of a separate superheater it may be interesting to investigate the possibility of varying the electrical output of the plant by altering the heat input to the superheater with no change of the heat loading on the reactor. If the turbine could be operated over the full temperature range at inlet, that is, between 450 and 900 deg. F., it would be theoretically possible to vary the output of the plant to about 70 per cent. of full load by control of heat input to the superheater alone. It is highly improbable, however, that rapid load changes could be dealt with in this way without causing damage to the machine through thermal shock.

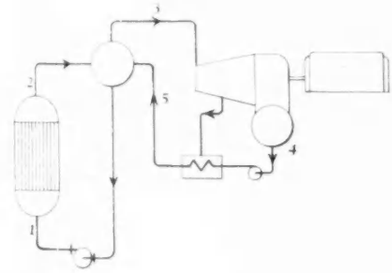
If the use of an auxiliary combustion fuel is excluded, because of restrictions with regard to the site or for other reasons, the problem remains of choosing the best method for handling saturated steam in the turbine. The ideal would be to expand the saturated steam through the turbine without recourse to any external reheater or water separator. Various methods of water drainage from separate turbine stages are employed in existing turbine designs. A proportion of moisture present in the steam can be collected from the outer periphery of a stage and the collected condensate can be discharged through suitable ducts. This condensate can then be drained to a feed-heating stage or to the main condenser. As much as 40 per cent. of the moisture

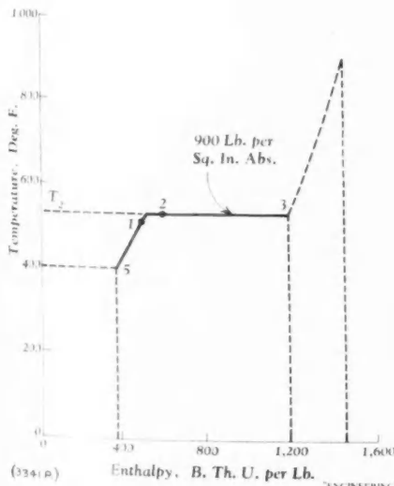
present can xtracted in this manner in favourable circumstanc It does not seem impossible to design a satisfacto turbine, incorporating a number of separate dra ge points to enable saturated steam





(a)





(b)

Fig. 7 If version of the reactor coolant directly into stea permitted, then two alternatives are possible: the flash-steam cycle, in which bulk boiling is suppressed within the core and steam generatio kes place in a separate flash vessel outside t actor; and (b) the boiling-water cycle in which k boiling occurs inside the reactor vessel. gh thermodynamically efficient, both present lems of radioactive contamination.

at a pressure of 420 lb. per square inch to be used, without excessive trouble from blade erosion.

If water is to be used in a reactor as the coolant and moderator, there is a natural incentive to use this water directly for the generation of steam. The external heat-exchanger would then be discarded and the steam pressure in the boiler drum could approach the pressure inside the reactor vessel. There are two main alternatives, both represented in Fig. 7: (*a*) a flash-boiling system in which bulk boiling of the water would be just suppressed inside the core and the generation of steam would take place mainly outside the reactor in a separate flash vessel, and (*b*) a boiling-water reactor in which bulk boiling is allowed to occur inside the reactor vessel itself. In either case there is the problem of the possible contamination of the turbine with radioactive material.

Under normal operating conditions the level of activity at the turbine should not be serious, but in the event of a fuel-element failure, some difficulty might be experienced in decontaminating the external unit. The feasibility of the direct use of steam from a reactor will depend both on the speed with which a rise in activity can be detected, and the steam flow diverted from the turbine, and on the successful design of a fuel element which will not deteriorate rapidly in the event of a minor fault developing in the sheath.

FLASH-STEAM REACTORS

The flash-steam cycle, which was first put forward by Sir Christopher Hinton in his James Clayton lecture (ENGINEERING, vol. 177, page 313, 1954), is shown diagrammatically in Fig. 7(*a*). Sub-cooled water at state 1 enters the reactor and is heated as a single-phase fluid to state 2, that is, up to the boiling point at the reactor pressure. This implies that the surface temperature of the fuel elements is maintained at some value higher than the boiling point of the water and some local nucleate boiling will therefore occur adjacent to the hottest parts of the fuel-element heat-transfer surface. Bulk boiling in the core, however, would be just suppressed.

Hot water emerges from the reactor at the boiling point corresponding to the reactor pressure, and is then throttled to the separator where part of the water flashes into steam. This process is represented on the temperature-enthalpy diagram by the short vertical line from point 2. Steam at state 3 can then be passed either directly to the turbine or through a separate superheater. Hot water from the separator at state 6 is mixed with feed-water from the feed-pump and the mixed stream passes to the main circulating pump, and thence to the reactor inlet at state 1.

FULL BOILING SYSTEMS

The full boiling system is shown diagrammatically in Fig. 7(*b*). Bulk boiling now takes place inside the reactor core and a steam-water mixture emerges from the core and passes to the boiler drum. The reactor coolant channels thus take the place of the evaporator section of a conventional boiler. Forced circulation may be employed to maintain the necessary velocities and heat-transfer rate from the core. Apart from the drop of pressure occurring in the main steam and water lines, the boiler pressure in the boiler drum is now identical with the pressure inside the reactor vessel.

Thermodynamically, the full boiling system is undoubtedly the ideal one, and a fairly high steam pressure can be achieved at the turbine stop-valve without the necessity to maintain a much higher pressure in the reactor itself.

One reason for considering the flash-steam or boiling cycle is the desirability of easing the pressure-vessel design problem. In the flash-steam reactor heat is removed from the core without change of phase of the coolant. It can be assumed in the limiting case, however, that the water is heated up to the boiling point corresponding to the reactor pressure. In these circumstances, the permissible temperature level may be fixed by the maximum temperature in the fuel elements rather than by the design pressure for the reactor vessel. Fig. 8 shows a design for a pressure vessel to house a reactor of moderate size (Markham and Company, Limited).

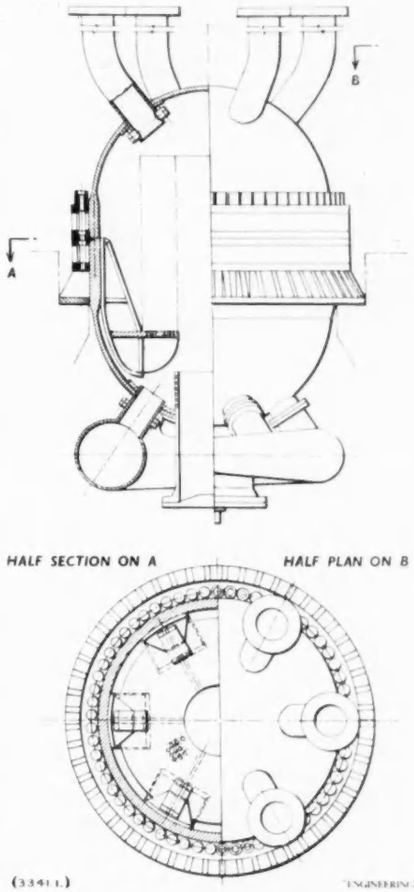


Fig. 8 Suitable pressure vessel for flash-steam reactor, which though not as efficient thermodynamically as the boiling system, presents fewer pressure-vessel design problems. (Markham and Company).

With full boiling of the coolant occurring inside the core, heat will be extracted from the reactor almost entirely through the latent heat of the steam. A natural circulation system would be possible with this arrangement, but to maintain sufficiently high flow velocities forced circulation would probably be desirable. With water returned to the reactor at the saturation temperature, however, trouble would be experienced with cavitation on the suction side of the pump and a certain degree of sub-cooling would in fact be necessary.

A definite limit will be placed by the nuclear-physics requirements on the permissible proportion of steam formed inside the coolant channels. This will necessitate the use of relatively larger channels, a high rate of circulation of the steam-water mixture, and some degree of sub-cooling of the water returning to the reactor. To meet these requirements it may in fact be necessary to design a reactor which is really a compromise between the true boiling reactor and the flash-steam reactor, and thus to arrange matters so that some of the boiling takes place outside the core.

The plant arrangement for the boiling reactor would therefore be essentially similar to that for the flash-steam reactor, but the circulating pumps would be smaller. The steam drum or drums would

TABLE V.—CIRCULATION RATES AND THEORETICAL CYCLE EFFICIENCIES

	Flash Cycle				Boiling Cycle
Reactor pressure, lb. per sq. in.	900	900	900	900	900
Flash-vessel pressure, lb. per sq. in.	500	600	700	800	900
Circulation ratio	9·8	13·3	20·2	40·7	—
Feed temperature, deg. F.	330	345	360	375	375
Heat from reactor, B.Th.U. per lb. steam	887	871	851	834	847
Turbine work, B.Th.U. per lb. steam	283	282·5	282	282	287
Pump work, B.Th.U. per lb. steam	16·7	17·3	17·6	17·9	—
Net work, B.Th.U. per lb. steam	266	265·2	264·5	264·1	287
Theoretical cycle efficiency, per cent.	30·0	30·5	31·1	31·7	33·8
Steam flow for 500 MW reactor heat, lb. per hr.	$1{\cdot}92 \times 10^6$	$1{\cdot}96 \times 10^6$	$2{\cdot}0 \times 10^6$	$2{\cdot}04 \times 10^6$	$2{\cdot}01 \times 10^6$
Water circulation rate for 500 MW reactor, lb. per sec.	5,240	7,240	11,250	23,100	—

again be mounted above the reactor vessel, but they could be reduced in size if sufficient space were provided above the core inside the reactor vessel to enable some separation of steam and water to take place before the steam passes out of the reactor vessel to the drums. The circulation rates and theoretical cycle efficiencies for a range of flash vessel pressures and the corresponding figures for the full boiling cycle are given for comparison in Table V.

Two arrangements for the boiling-water reactor are shown in Fig. 9; the first (*a*) represents a system with saturated steam and water separation, while the second (*b*) is a scheme with external superheating

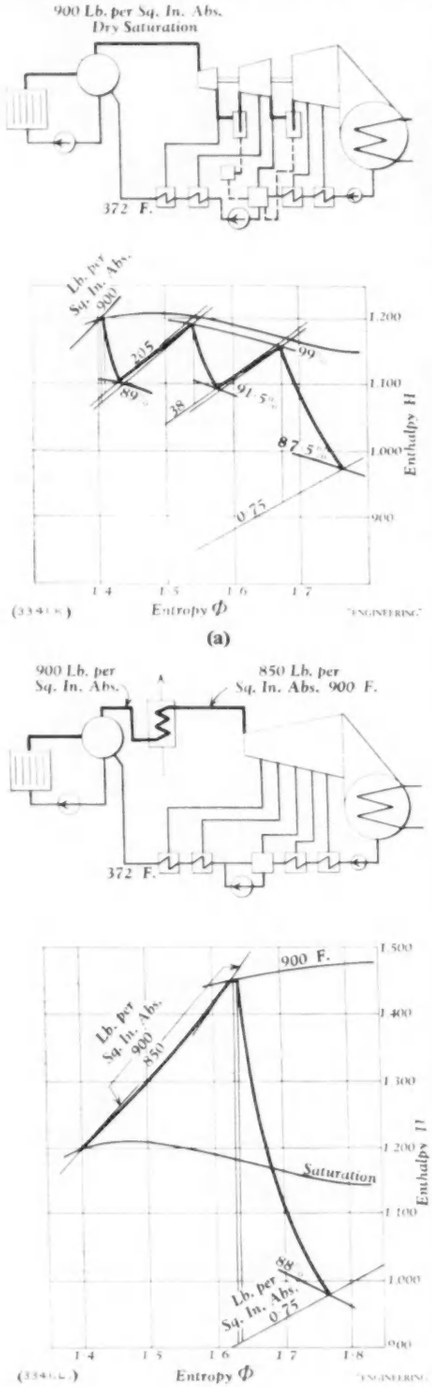


Fig. 9 Two steam cycle arrangements for a boiling-water reactor: (a) saturated steam with water separation; (b) external superheating from a combustion source.

TABLE VI. *Comparison of Two Steam Cycles for a Boiling-Water Reactor*

	Water Extraction	Separate Superheater
Boiler pressure, lb. per sq. in. abs.	900	900
Turbine stop-valve pressure, lb. per sq. in. abs.	900	850
Turbine stop-valve temperature, deg. F.	532	900
Back pressure, lb. per sq. in. abs.	0·75	0·75
Final feed temperature, deg. F.	372	372
Turbo-generator efficiency, per cent.	31·5	35·4
Electrical output, MW	157·5	230
Steam to turbine, lb. per hr.	2,000,000	2,000,000
Steam to condenser, lb. per hr.	1,072,000	1,320,000
Exhaust area for assumed leaving loss, sq. ft.	131·5	161·5

from a combustion source. Table VI gives a comparison of the two cycles.

Pressurised-water reactors are sometimes compared unfavourably with either gas-cooled or sodium-cooled reactors, on the basis of the available coolant outlet temperature. This, however, is not a valid basis for comparison. With water-cooled reactors temperatures throughout the core are more nearly uniform than in any other known type of reactor. The boiler pressure is determined by the coolant return temperature and not by the outlet temperature. In terms of steam conditions and cycle efficiencies, the pressurised-water reactor appears in a much more favourable light.

ECONOMIC ESTIMATE

Although it is hazardous to attempt a precise estimate of power generation costs until a prototype plant has been operated, it is possible, by making certain reasonable assumptions, to obtain some indication of what these costs are likely to be. Two cases are considered, each with a reactor heat rating of 500 MW: (1) an orthodox pressurised-water reactor with an electrical output of 135 MW at a capital cost of £100 per kW installed; and (2) a boiling-water or flash-steam reactor with an electrical output of 150 MW at a capital cost of £90 per kW installed. In each case therefore, the total capital cost of the plant is £13·5 million. Table VII, which

TABLE VII. *Cost of Power Generation for Orthodox Pressurised and Boiling Water Reactors in Pence per kW-hr. Sent Out*

Load factor, per cent.	50	60	70	80
(a) Orthodox reactor				
Capital charges	0·420	0·350	0·301	0·263
Fuel cost	0·140	0·140	0·140	0·140
Operating cost	0·100	0·100	0·100	0·100
Total	0·660	0·590	0·541	0·503
(b) Boiling reactor				
Capital charges	0·378	0·314	0·269	0·236
Fuel cost	0·126	0·126	0·126	0·126
Operating cost	0·100	0·100	0·100	0·100
Total	0·604	0·540	0·495	0·462

refers to the saturated steam case using reactor heat alone, gives the estimated total cost of power-generation expressed in pence per kW-hr. sent out.

The principal merit of the water-moderated reactor is the prospect that it offers of meeting a wide range of power-station requirements with a single basic type of design. Once the characteristic engineering problems of a pressurised-water system have been solved, a number of variations in design become possible without incurring new problems on each occasion. If heavy-water is available, natural uranium may be used as the fuel. If enriched fuel is available, ordinary water may be used as the moderator and, by increasing the degree of enrichment successively, smaller reactor cores may be employed. A very wide range of power output can thus be covered from the same basic design. Finally, there is the prospect of development from the orthodox pressurised-water reactor to some form of boiling-water reactor.

The real criterion as to whether one type of nuclear reactor is better than another will be reliability and convenience of operation rather than the efficiency or even the cost of the plant. A decision on this point can be made only in the light of actual operating experience. The best type of liquid-cooled reactor will probably be the reactor having the simplest type of fuel element, and preferably a fuel element which will deteriorate only slowly in the event of a minor imperfection or failure in the sheath.

APPROVAL AND DISSENT

Following the presentation of the paper, "The Pressurised Water Reactor as a Source of Heat for Steam Power Plants," by J. M. Kay and F. J. Hutchinson at a general meeting of the Institution of Mechanical Engineers on December 14, 1955, the subject was discussed under the chairmanship of Mr. P. L. Jones, M.C., B.Sc., Wh.Ex., President of the Institution. The article above is an abridged version of the paper. Some points from the discussion are given below.

PROBLEMS OF CORE DESIGN

In opening the discussion Mr. R. V. Moore, G.C., observed that possibly the two major shortcomings of the pressurised-water method were the following. First, although water was considered normally to be a non-corrosive agent, at high temperatures it was just the reverse; in particular, its attack on uranium metal was violent. Secondly, at atmospheric pressure it boiled at 100 deg. C., and consequently the input to the turbines was low-pressure saturated steam. Water, while being generally an excellent low-temperature coolant, had many shortcomings for high-temperature applications.

The problem of core design, on which 80 to 90 per cent. of the research and design problems was concentrated, was perhaps somewhat under-emphasised in the paper. This he believed had led to an over estimation of heat and power output—a view to some extent substantiated by the figures for a similar American reactor now under construction, having a 9 ft. diameter pressure vessel pressurised to 2,000 lb. per square inch. Its design output was 290 MW (heat) and 85 MW (electrical), which was considerably less than the estimates given in the paper. He was also of the opinion that comparisons of proposed plants could not be made with any success on an estimated economic basis.

With regard to the reactor core it was possible to distinguish four major groups of problem: (i) fuel-element design and performance; (ii) the heat rate of a reactor of specific size; (iii) the neutron economy of the core; and (iv) the accommodation of operational requirements. In group (iv) particular attention should be paid to (*a*) arrangements for loading and unloading the fuel, (*b*) the control of the reactor in the steady-state and in the transient states associated both with normal load changing and fault conditions, and (*c*) the detection, localisation and methods of dealing with faulty fuel elements. These factors were completely interlocking, and it was important to strike the right balance.

The highly corrosive properties of high-temperature water on uranium constituted a major embarrassment to the successful development of a satisfactory fuel element. Alloys of uranium which were more resistant to attack had been found, but they were expensive in neutrons and appeared to detract from the ability of the fuel to withstand radiation damage. It was interesting to note that, in the pressurised-water reactor under construction at Shippingport, the Americans were using uranium oxide as the fuel, and the core had a circumferential zone of zirconium fuel elements in which almost pure fissile material was uniformly dispersed. This fuel element behaved basically as zirconium. The uranium oxide, of course, had a much lower density than the metal and was difficult to process after irradiation, while the zirconium fuel elements were probably very expensive.

Plant capital costs per kW-hr. sent out were always reduced by increasing the rating of the fuel, with the subsequent reduction in reactor size for a given output. Some 20 per cent. of the capital cost of the plant could be affected in this way. If this increase in rating, however, could be achieved by an increase in the maximum temperature of the system, the reduction in capital cost could be extended not only to the reactor but also to the steam plant, and a much larger proportion of the capital cost would be affected. There seemed little prospect of achieving this in pressurised-water plants. It was perhaps ironical that zirconium, a metal with a low capture cross-section and a melting point of 1,900 deg. C., had to be introduced into pressurised-water plants to resist corrosion effects, and yet could not be used to raise the operating temperature of the system.

HIGH COST OF HEAVY WATER

The neutron economy of a practical light-water system did not permit the use of natural uranium as fuel; it would thus be necessary to use heavy water. The capital cost of building a large heavy-water production plant, given present techniques, was believed to be about £70 per lb. per annum. The adoption of a heavy-water reactor as the standard commercial reactor would therefore imply a large production programme, since about ton of heavy water was required for each megawatt of electrical capacity installed. This would mean that by1965-70 a heavy-water plant of 2,000 to 3,000 tons per annum capacity would be needed, and the capital investment involved would be some £300 million to £450 million.

The second speaker, Mr. D. R. Griffiths, also cast

doubts on the economic conclusions reached in the paper, like those commenting on the inadequate treatment of core design. The authors had stressed reliability and convenience of operation as the main factors in selecting an atomic plant, but the speaker believed that the real criterion was the true average cost of useful power produced over the life of the station, which of course took into account reliability and availability. A most important factor was fuel cost which was affected by both thermodynamic and nuclear efficiency, and it was in attempting to obtain high nuclear efficiency—in other words, a high conversion factor consistent with low fuel enrichment—that most of the difficulties arose.

LOW NUCLEAR EFFICIENCY?

Thus the Russian pressurised-water reactor, though it was undoubtedly a sound engineering job, required uranium of sevenfold enrichment and had a conversion factor of only 0·3; it could therefore never produce power at a reasonable cost. This was a very important consideration in view of the present high cost of nuclear fuel. However, the economic estimates given in the paper did not, of course, relate to the Russian type of core.

With half-inch diameter rods sheathed in stainless steel $\frac{1}{16}$ in. thick, plus additional structural material in the form of coolant tubes and other components, the calculated enrichment for such a core would be at least twice the uranium 235 concentration of natural uranium and the conversion factor on a plutonium re-cycling basis with non-alloyed fuel elements would be less than 0·65. This made no allowance for flux flattening, but with more or less ideal flattening, as suggested, and the use of alloying materials to make the fuel elements resistant to water corrosion in the event of a can failure, the enrichment factor would be much higher and the conversion factor lower, possibly 2·5 and 0·6 respectively.

Although the differences in these factors from those assumed were sufficient to alter completely the economics presented in the paper, with suitable core design and progress in other fields of development, for example, fuel element processing, those responsible at Harwell were fairly confident that generation costs from such reactors could be brought down to a figure approaching that given.

BOILING VERSUS NON-BOILING

In the estimates for boiling reactors the authors assumed that the capital cost per kilowatt and fuel cost per kilowatt-hour varied inversely as the efficiency. From the figures presented it might be concluded that boiling reactors would produce power at a lower cost than non-boilers. This was erroneous. It was generally agreed that the heat output obtainable from a given size of core under boiling conditions was very much less than under non-boiling conditions, because of such considerations as fuel-element burn-out, moderator-density variations, hydraulic stability, so that for a given output an appreciably larger core would be necessary in the boiling case.

In addition, there was the extra cost associated with reactivity control, corrosion control, steam and water separation, and the radioactive steam and feed. The higher thermodynamic efficiency achievable with a boiler needing no heat exchangers would be partly, if not wholly, offset by the decreased nuclear efficiency. Furthermore, in the event of fuel-element failures, some fission products, including gases, would be carried over and deposited throughout the plant making maintenance extremely hazardous.

Other points made by the speaker included reference to the formidable difficulties associated with fuel-element discharge and the detection of burst slugs; a call to turbine manufacturers to be ready, in the event of a decision to proceed with pressurised-water reactors, to undertake the development of saturated-steam turbines; an observation that no allowance had been made in the authors' economic estimates for auxiliary power needs; and an assurance that all the problems concerned with the design of water-moderated reactors had been or could be overcome.

PRESSURE-SHELL METALLURGY

The metallurgical aspects of water-moderated reactors were discussed by Dr. A. B. McIntosh, head of the Culcheth Laboratories of the United Kingdom Atomic Energy Authority Industrial Group, who outlined some of the difficulties likely to be met. First, the was the pressure vessel of mild steel. The author spoke of fabricated vessels $7\frac{1}{2}$ in. in wall thickness, 9 or 10 ft. in diameter, and approximately in height. It should be noted that no steelmaker would guarantee to make homogeneous plate in thickness. In addition, owing to the thickness would be necessary to reduce the size of the , thus adding to the welding problems. If stainless steel were chosen, there was as yet no technique available in this country for making sound welds in such thicknesses of plate, nor was it possible to ensure proper standards of fault detection.

Nuclear reactions would be taking place within the vessel and the material for the shell must be chosen accordingly. With the evolution of atomic energy, there would be diffusion into the pressure shell, and if this were made of mild steel, there would be reaction with carbides, possibly producing methane; in the worst cases methane blisters might form with consequent intergranular separation. To prevent this an alloy steel such as chromium steel might be used but the resulting welding problems would be almost insuperable.

The use of a clad steel had been suggested, but clad steels presented their own difficulties. There would still be diffusion of atomic hydrogen, with the possibility of blister formation at any discontinuity between the cladding and the plate. With cladding of stainless steel, or even stainless-steel plate, there was the danger of stress corrosion cracking by demineralised and de-oxygenated water. This was particularly likely to occur in alternate wet and dry conditions.

FUEL-ELEMENT CORROSION

With regard to the fuel elements, the difficulties of selecting materials arose from the extremely corrosive nature of the pressurised water. No satisfactory material was at present available, but at various times stainless steel, zirconium alloys and aluminium alloys had been considered.

In the presence of irradiation there might be substantial and persisting dimensional changes of the fuel, and the resulting stress-corrosion conditions had also to be considered. With alternative canning materials such as zirconium alloys or aluminium alloys dangers might arise from pitting corrosion or from metallurgical defects; but whether corrosion was due to pitting or stress the effect would be the same; there would be intense corrosion of the uranium fuel with a rapid release of fission products accompanied by pressure increase due to hydrogen evolution.

In the search for corrosion-resistant materials, alloys containing percentages of molybdenum and niobium had been studied, as had non-metallic oxides of low reactivity, but with both alloys and oxides it was necessary to increase enrichment. To date, in the case of so-called corrosion-resistant fuels, corrosion had only been delayed for an induction period, but subsequently corrosion took place catastrophically; from this it followed that first detection became very difficult. Moreover, the use of an alloy fuel or can (perhaps bonded to the fuel) complicated the plutonium recovery process.

Most of these troubles could be alleviated if the temperature of the pressurised reactor were reduced, but it would then only be useful as a plutonium producer. Finally, it should be noted that the disasterous effect on fuel-element corrosion of pressurised water might necessitate a degree of containment which would seriously diminish the attractivness of such reactors.

OTHER POINTS IN BRIEF

Pressures and Temperatures. One of the advantages stated by the authors for the flash-steam reactor was that it could operate at a lower pressure than the presurised-water reactor. Indeed, the operation of the former depended on the water temperature from the outlet being close to the maximum fuel-element surface temperature. In the examples given in the paper, the pressure in the pressurised-water reactor was high enough for the saturation temperature to be in excess of the maximum fuel temperature, whereas in the flash-steam reactor the reverse was the case. If safe operation could be assured for the flash-steam reactor under these conditions, could the same conditions not be applied to the pressurised-water reactor, thus easing the pressure-vessel design problem? (Professor J. Diamond.)

Dual Scheme for Superheating and Heavy-Water Production. As the nuclear power programme developed, it would be necessary for the supply industry to look for more load to keep the plants in full operation during the night. There was relatively little pumped storage in England, although the situation in Scotland was more favourable. A suitable outlet might be found in the large-scale hydrolysis of water for heavy-water concentration, and the hydrogen produced in this way could be used for steam superheating. Sufficient hydrogen could be stored each day to permit the electrolytic plant to be shut down during peak-load periods. If nuclear energy fuel costs were sufficiently low—and there was evidence that they would be—it was possible that a dual-purpose system of this kind might provide supplies of heavy water at a price which would make the heavy-water reactor more attractive than it was at present. Attention was also drawn to the limitations imposed by the comparatively low-temperature working. (Mr. T. R. Warren.)

Plutonium as a Fuel and Standard Turbines. The problem of fuel enrichment was touched upon once more; a uranium 235 separation plant was very expensive and plutonium might prove difficult to burn. Concerning superheaters it might be said that although they gave high efficiency their main advantage was that they enabled standard turbines to be used and simplified the development problem. (Mr. B. L. Goodlet).

Fuel Supplies and Reactor Exports. Although fuel for a pressurised-water reactor was not yet available, it should be ten years hence when some of the gas-cooled reactors were in operation. It was important seriously, to consider the potential export market and to that end we should devote some of our resources to proving the pressurised-water reactor on a prototype scale. (Mr. G. Kennedy).

Edison Pressurised-Water Reactor. Attention was drawn to the announcement by the Consolidated Edison Company of New York that they intended to proceed with a pressurised-water reactor having an electrical output of 236 MW, and costing overall some 55 million dollars. This represented a cost of £83·5 per kW, which was substantially lower than any figure the speaker had yet seen for a nuclear generating station. (Mr. G. Kennedy.)

Conventional-Fuel Superheating. The advantages of separate superheating and the mixing of nuclear and fossil fuels were borne out by the Consolidated Edison reactor, which would have a very great addition of conventional fuel heating in the cycle; this no doubt played a considerable part in making possible the low capital cost. (Mr. R. V. Wootton).

AUTHORS' REPLIES

The authors then replied to points made by speakers.

Turbine Throwbacks? It had been said that the impact of nuclear energy, with the steam conditions which it entailed, would throw back turbine design to where it had been 25 years ago. That was not so. The 400 lb. per square inch turbines of 25 years ago were of only some 25 MW capacity, but in the paper 100 to 125 MW ratings were under discussion. It was in any case a question of only passing importance and probably would not arise. (Mr. F. J. Hutchinson).

Dispensing with the Extra Superheater. Since the introduction of secondary fuels for superheating the steam was manifestly undesirable, the means of producing the required result without an additional superheater would undoubtedly be established within a reasonable time. Furthermore, it must not be forgotten that it was extremely likely that a turbine designed for an initial pressure and temperature such as had been discussed, with a capacity of 100 MW, had to have one or two reheat sections, and the superheater, which would be fired by fuel of any kind, would also incorporate in it a reheating element. That appeared to have been overlooked, but it would no doubt be realised that this was true. (Mr. F. J. Hutchinson).

Turbine Amortisation. The main problem in connection with turbines was their length of life when supplied with steam in the conditions indicated. In other words, the designers had to produce a machine which would last for at least the amortisation period of 20 to 25 years, and the two main considerations were the question of water and the leaving losses at the exhaust end. There was a tendency to think that the difficulties of turbine design would be in the back end of the turbine—the water end. Admittedly there were difficulties there, but it was likely that the high-pressure and intermediate-pressure cylinders would also have their design difficulties, owing to the probable wetness of the steam. The decreased peripheral speed of the blades at the exhaust end pointed to a machine of 1,500 r.p.m. rather than one of 3,000 r.p.m. It was reasonable to suppose that the 1,500 r.p.m. machine was basically lower in efficiency than the 3,000 r.p.m. machine and the cost greater.

In the event of the steam being reheated, the close-coupled cross-compound arrangement would have to be examined; the high-pressure spindle would be a machine at 3,000 r.p.m. and the steam would be taken from it, reheated and returned to a second turbine at 300 r.p.m., which would probably produce two-thirds of the total power of the combined turbine. In those circumstances there was no difficulty in connecting the two alternators together. (Mr. F. J. Hutchinson).

Light-Water Reactor Defended. Mr. Moore had given a long list of the problems which would be encountered with the light-water reactor, and it was a formidable list; but it would be possible to compile similar lists for gas-cooled and liquid-metal-cooled reactors, and indeed for any other type. The problems were certainly difficult but the water-cooled reactor should not be discarded on that account. Dr. J. M. Kay.)

STRESSES IN BOILER TUBES

ROUTINE PROCEDURE SUITABLE FOR DESK CALCULATING MACHINE

By E. W. Parkes, M.A., PH.D., A.M.I.C.E.*

A routine procedure is presented for the determination of the stresses in a continuous boiler tube which is not confined to one plane. One end of the tube is presumed encastred and the other subjected to known movements; the method is thus particularly suitable for the analysis of stresses due to thermal expansion.

The following article aims at establishing a routine calculational method for the analysis of the stresses in a tube consisting of straight lengths joined by plane circular arcs: the tube is not confined to one plane, and the ends are subjected to known displacements and rotations. The problem is of particular interest in the design of water-tube boilers.†

A conventional strain energy approach is used—the object being not to present anything analytically novel, but to develop a standard procedure for the determination of the stresses in any boiler tube and to present the results in the form of calculation sheets which can be filled in by comparatively unskilled labour with the minimum of guidance. With this object in view, the results of the investigation are given as a set of rules in the section "Systematical Calculation." They can be used without reference to any other part of the text.

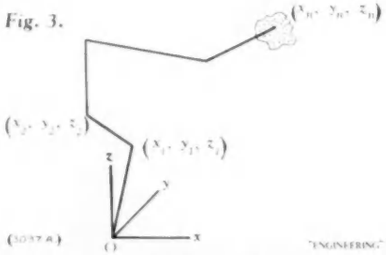
* Cambridge University Engineering Laboratory.

† This work was originally carried out by the author while acting as a consultant to John Brown and Company, Land Boiler Division. He is indebted to that company for permission to publish this article.

Fig. 1.

Fig. 2.

Fig. 3.



Figs. 1, 2 and 3 A boiler tube of straight portions joined by plane circular arcs (Fig. 1) can be considered as consisting of intersecting straight portions (Fig. 2). Fig. 3 shows the system of notation used in the analysis, with the origin at the free end.

MATHEMATICAL ANALYSIS

Consider a boiler tube such as that shown in Fig. 1, consisting of straight portions joined by plane circular arcs. End N of the tube is supposed encastré, while end O, due to temperature rise or some other cause, is subjected to known displacements and rotations. We have to find the stresses in the tube.

Now it can be shown (Appendix) that provided the curved portions of the tube do not occupy too great a proportion of the total length, and provided no individual bend exceeds 90 deg., then we may replace the actual curved tube by the continuations of the adjacent straight portions to their point of intersection, without appreciably affecting the stress distribution. (Bends greater than 90 deg. may be regarded as two adjacent smaller bends, see Fig. 5.) We thus obtain the kinked tube shown in Fig. 2, and it is this modified tube that it is proposed to analyse.

We set up any convenient system of co-ordinate axes Ox, Oy, Oz with origin at the free end of the tube and denote the first kink by (x_1, y_1, z_1), the second by (x_2, y_2, z_2) and so on up to the encastred end at (x_n, y_n, z_n) (see Fig. 3). Then portion 1 of the tube runs from (0, 0, 0) to (x_1, y_1, z_1), portion 2 from (x_1, y_1, z_1) to (x_2, y_2, z_2) and so on.

Let the tube be subjected at its free end to forces P_x, P_y, P_z in the directions of the co-ordinate axes and moments M_x, M_y, M_z (right-hand corkscrew rule) about them. Let these forces and moments produce displacements and rotations δ_x, δ_y, δ_z and θ_x, θ_y, θ_z. We shall be given δ_x, δ_y, δ_z, θ_x, θ_y and θ_z and have to find P_x, P_y, P_z, M_x, M_y and M_z in order to evaluate the stresses. We can do so, provided we know the total strain energy U of the tube, obtained from the equations

$$\frac{\partial U}{\partial P_x} = \delta_x, \text{ etc.} \quad . \quad . \quad (1)$$

The problem, then, is to evaluate the differential coefficients $\partial U/\partial P_x$, etc.

Consider portion r of the tube (Fig. 4), of length

$$l_r = \{(x_r - x_{r-1})^2 + (y_r - y_{r-1})^2 + (z_r - z_{r-1})^2\}^{\frac{1}{2}} \quad (2)$$

and making angles with the co-ordinate axes of

$$\left.\begin{aligned} \cos^{-1}\frac{x_r - x_{r-1}}{l_r} &= \cos^{-1}\alpha_r \\ \cos^{-1}\frac{y_r - y_{r-1}}{l_r} &= \cos^{-1}\beta_r \\ \cos^{-1}\frac{z_r - z_{r-1}}{l_r} &= \cos^{-1}\gamma_r \end{aligned}\right\} \quad . \quad . \quad (3)$$

The moments about the co-ordinate axes at any point in portion r of the tube are given by

$$\left.\begin{aligned} M_{xr} &= M_x - P_z\,y + P_y\,z \\ M_{yr} &= M_y - P_x\,z + P_z\,x \\ M_{zr} &= M_z - P_y\,x + P_x\,y \end{aligned}\right\} \quad . \quad . \quad (4)$$

whence the torque in the member is given by

$$T_r = \alpha_r M_{xr} + \beta_r M_{yr} + \gamma_r M_{zr} \quad . \quad (5)$$

and the bending moment, M_r, is given by

$$M_r^2 = (\alpha_r^2 + \beta_r^2) M_{zr}^2 + (\beta_r^2 + \gamma_r^2) M_{xr}^2 + (\gamma_r^2 + \alpha_r^2) M_{yr}^2 - 2\alpha_r\beta_r M_{xr} M_{yr} - 2\beta_r\gamma_r M_{yr} M_{zr} - 2\gamma_r\alpha_r M_{zr} M_{xr} \quad . \quad . \quad . \quad (6)$$

The total strain energy of the tube strictly

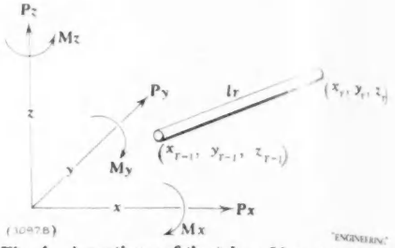


Fig. 4 A portion r of the tube, of length l_r, has the co-ordinates shown. This is the generalised portion considered in the analysis.

consists of four terms, those due to bending, torsion, end load and shear, but except in certain trivial cases the terms due to end load and shear are negligible and it is sufficiently accurate to consider the first two only. In this case, the total strain energy of portion r of the tube, U_r, is given by

$$EIU_r = (1 + \nu)\int_{s_{r-1}}^{s_r} \frac{T_r^2}{2}\,ds + \int_{s_{r-1}}^{s_r} \frac{M_r^2}{2}\,ds \quad . \quad . \quad . \quad (7)$$

where EI is the flexural rigidity of the tube, ν is Poisson's ratio and s a co-ordinate measured along the tube (it should be remembered that for a circular tube, flexural rigidity/torsional rigidity $= 1 + \nu$).

For eventual insertion in equations (1) we shall require the differentials of U_r with respect to the applied forces, for example

$$EI\frac{\partial U_r}{\partial M_x} = (1 + \nu)\int_{s_r}^{s_{r-1}} T_r\frac{\partial T_r}{\partial M_x}\,ds + \int_{s_r}^{s_{r-1}} \tfrac{1}{2}\frac{\partial (M_r^2)}{\partial M_x}\,ds. \quad . \quad . \quad . \quad (8)$$

Substituting from equations (4), (5) and (6) and noting that

$$\left.\begin{aligned} \int_{s_{r-1}}^{s_r} ds &= l_r \\ \int_{s_{r-1}}^{s_r} x\,ds &= \frac{l_r(x_r + x_{r-1})}{2}, \text{ etc.} \end{aligned}\right\} \quad . \quad (9)$$

$$\begin{aligned} EI\frac{\partial U_r}{\partial M_x} &= M_x(1 + \nu\alpha_r^2)\,l_r \\ &\quad + M_y\,\nu\alpha_r\beta_r\,l_r + M_z\,\nu\alpha_r\gamma_r\,l_r \\ &\quad + P_x\frac{l_r}{2}\{\nu\alpha_r\gamma_r(y_r + y_{r-1}) - \nu\alpha_r\beta_r(z_r + z_{r-1})\} \\ &\quad + P_y\frac{l_r}{2}\{(1 + \nu\alpha_r^2)(z_r + z_{r-1}) - \nu\gamma_r\alpha_r(x_r + x_{r-1})\} \\ &\quad + P_z\frac{l_r}{2}\{-(1 + \nu\alpha_r^2)(y_r + y_{r-1}) + \nu\beta_r\alpha_r(x_r + x_{r-1})\}. \end{aligned} \quad (10)$$

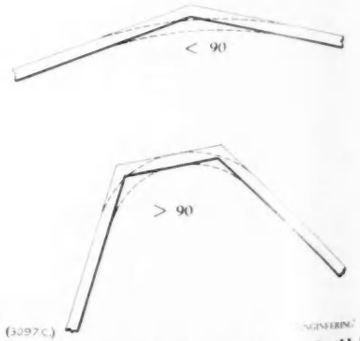


Fig. 5 Curves of less than 90 d[eg.] should be replaced by a kink at the point of i[nter]section of the adjacent straight portions. C[urv]es greater than 90 deg. should be replaced [by] two kinks.

INFLUENCE COEFFICIENTS, PORTION r =
$I_r^3 = \Sigma\, \delta^3 =$ $I_r =$

	A	B	C
1	x_r	y_r	z_r
2	I^2	I^2	I^2
3	x_{r-1}	y_{r-1}	z_{r-1}
4	3^2	3^2	3^2
5	$1 - 3$	$1 - 3$	$1 - 3$
6	$1 + 3$	$1 + 3$	$1 + 3$
7	$1 \quad 3$	$1 \quad 3$	$1 \quad 3$
8	$2 + 4 + 7$	$2 + 4 + 7$	$2 + 4 + 7$
9	$5 I_r$	$5 I_r$	$5 I_r$
10	9^2	9^2	9^2
11	$1 - \nu\ 10$	$1 + \nu\ 10$	$1 + \nu\ 10$
12	$I_r\ 11$	$I_r\ 11$	$I_r\ 11$
13	$\nu\ 9A\ \ 9B$	$\nu\ 9B\ \ 9C$	$\nu\ 9C\ \ 9A$
14	$I_r\ 13$	$I_r\ 13$	$I_r\ 13$
15	$11C \quad 6B$	$11A \quad 6C$	$11B \quad 6A$
16	$\{15A - 15B\}/2$	$\{15B - 15C\}/2$	$\{15C - 15A\}/2$
17	$12A \quad 6C$	$12B \quad 6A$	$12C \quad 6B$
18	$11C \quad 6A$	$11A \quad 6B$	$11B \quad 6C$
19	$\{17 - 18\}/2$	$\{17 - 18\}/2$	$\{17 - 18\}/2$
20	$14 \quad 6$	$14 \quad 6$	$11 \quad 6$
21	$12A \quad 6B$	$12B \quad 6C$	$12C \quad 6A$
22	$\{20 - 21\}/2$	$\{20 - 21\}/2$	$\{20 - 21\}/2$
23	$1A \quad 1B$	$1B \quad 1C$	$1C \quad 1A$
24	$1A \quad 3B/2$	$1B \quad 3C/2$	$1C \quad 3A/2$
25	$3A \quad 3B$	$3B \quad 3C$	$3C \quad 3A$
26	$3A \quad 1B/2$	$3B \quad 1C/2$	$3C \quad 1A/2$
27	$23 + 24 + 25 + 26$	$23 + 24 + 25 + 26$	$23 + 24 + 25 + 26$
28	$12C \quad 8B$	$12A \quad 8C$	$12B \quad 8A$
29	$12B \quad 8C$	$12C \quad 8A$	$12A \quad 8B$
30	$-2 \quad 34C$	$-2 \quad 34A$	$-2 \quad 34B$
31	$\{28 + 29 + 30\}/3$	$\{28 + 29 + 30\}/3$	$\{28 + 29 + 30\}/3$
32	$-11A \quad 8C$	$-11B \quad 8A$	$-11C \quad 8B$
33	$-12C \quad 27A$	$-12A \quad 27B$	$-12B \quad 27C$
34	$11C \quad 27B$	$11A \quad 27C$	$11B \quad 27A$
35	$11B \quad 27C$	$11C \quad 27A$	$11A \quad 27B$
36	$\{32 + 33 + 34 + 35\}/3$	$\{32 + 33 + 34 + 35\}/3$	$\{32 + 33 + 34 + 35\}/3$

Fig. 6 Influence coefficients for portion r of the tube, of length l_r. One such sheet must be filled in for each portion of the tube to an accuracy of at least seven figures. The italic numbers and letters refer to rows and columns of the calculation sheet.

The corresponding differential with respect to end load can also be evaluated. We require in addition to the previous integrals,

$$\left.\begin{aligned}\int_{S_{r-1}}^{S_r} x^2\, ds &= \frac{l_r}{3}(x_r^2 + x_r x_{r-1} + x_{r-1}^2), \text{ etc.}\\ \int_{S_{r-1}}^{S_r} xy\, ds &= \frac{l_r}{6}\{2x_r y_r + x_r y_{r-1} + x_{r-1} y_r + 2x_{r-1} y_{r-1}\}, \text{ etc.}\end{aligned}\right\} \quad (11)$$

Then, $EI \dfrac{\partial U_r}{\partial P_x}$

$$\begin{aligned}
&= M_x \frac{l_r}{2}\{\nu\alpha_r\gamma_r(y_r + y_{r-1}) - \nu\alpha_r\beta_r(z_r + z_{r-1})\}\\
&+ M_y \frac{l_r}{2}\{-(1+\nu\beta_r^2)(z_r + z_{r-1}) + \nu\gamma_r\beta_r(y_r + y_{r-1})\}\\
&+ M_z \frac{l_r}{2}\{(1+\nu\gamma_r^2)(y_r + y_{r-1}) - \nu\beta_r\gamma_r(z_r + z_{r-1})\}\\
&- P_x \frac{l_r}{3}\{(1+\nu\gamma_r^2)(y_r^2 + y_r y_{r-1} + y_{r-1}^2) + (1+\nu\beta_r^2)(z_r^2 + z_r z_{r-1} + z_{r-1}^2) - \nu\beta_r\gamma_r(2x_r y_r + x_r y_{r-1} + x_{r-1} y_r + 2x_{r-1} y_{r-1})\}\\
&+ P_y \frac{l_r}{6}\{-2\nu\alpha_r\beta_r(z_r^2 + z_r z_{r-1} + z_{r-1}^2) - (1+\nu\gamma_r^2)(2x_r y_r + x_r y_{r-1} + x_{r-1} y_r + 2x_{r-1} y_{r-1}) + \nu\alpha_r\gamma_r(2y_r z_r + y_r z_{r-1} + y_{r-1} z_r + 2y_{r-1} z_{r-1}) + \nu\beta_r\gamma_r(2z_r x_r + z_r x_{r-1} + z_{r-1} x_r + 2z_{r-1} x_{r-1})\}\\
&+ P_z \frac{l_r}{6}\{-2\nu\alpha_r\gamma_r(y_r^2 + y_r y_{r-1} + y_{r-1}^2) - (1+\nu\beta_r^2)(2z_r x_r + z_r x_{r-1} + z_{r-1} x_r + 2z_{r-1} x_{r-1}) + \nu\alpha_r\beta_r(2y_r z_r + y_r z_{r-1} + y_{r-1} z_r + 2y_{r-1} z_{r-1}) + \nu\gamma_r\beta_r(2x_r y_r + x_r y_{r-1} + x_{r-1} y_r + 2x_{r-1} y_{r-1})\}
\end{aligned} \quad (12)$$

The differentials with respect to M_y, M_z, P_y and P_z can be found by cyclic interchange of the suffices.

The terms required in equations (1) are obtained by summing equations (10) and (12) over all portions of the tube, thus,

$$\frac{\partial U}{\partial P_x} = \sum_{r=1}^{r=n} \frac{\partial U_r}{\partial P_x}, \text{ etc.} \quad (13)$$

Substituting, and solving equations (1) we obtain the redundant forces and moments P_x, P_y, P_z, M_x, M_y and M_z. The bending moment and torque at any section of the tube can now be found from equations (4), (5) and (6) and the end load (compressive) from

$$P_r = \alpha_r P_x + \beta_r P_y + \gamma_r P_z. \quad (14)$$

The maximum comparison stress in the tube (i.e., that stress which is to be compared with the yield stress of the material when determining a factor of safety) is given by the von Mises formula as

$$\sigma_c = \left[\left\{\left|\frac{M_r}{Z}\right| + \left|\frac{P_r}{A_t}\right|\right\}^2 + 3\left\{\frac{T_r}{2Z}\right\}^2\right]^{\frac{1}{2}} \quad (15)$$

where Z is the section modulus of the tube and A_t its cross-sectional area. It will be noted in this that we have neglected the stress in the tube due to boiler pressure. Stresses due to steam pressure are generally small compared with those due to such causes as thermal expansion, but in doubtful cases they should be investigated. There are two effects to be considered: the hoop stress modifies equation (15), and there is a longitudinal contraction (due to the Poisson's ratio term) to be considered when evaluating δ_x, δ_y and δ_z.

We now have the formal solution to our problem; the computational procedure is given below.

SYSTEMATIC CALCULATION

The following notes give a method for the calculation of the stresses in a boiler tube consisting of straight lengths joined by plane circular arcs, when one end of the tube is given known displacements and rotations relative to the other. The work is presented simply as a set of arithmetic operations, shorn of the accompanying analysis, and has been arranged in what is believed to be the best form for use with a desk calculating machine.

The procedure is as follows:

(*a*) Replace the actual tube (Fig. 1) with one composed of a series of straight lengths formed by producing the actual straight portions to their points of intersection (Fig. 2). Bends greater than 90 deg. should be regarded as two smaller bends (Fig. 5).

(*b*) Set up any convenient system of Cartesian co-ordinates with origin at one end of the tube,

EQUATIONS FOR REDUNDANT FORCES AND MOMENTS.

P_x	P_y	P_z	M_x	M_y	M_z		
$\Sigma\ 31A$	$\Sigma\ 36A$	$\Sigma\ 36C$	$\Sigma\ 16A$	$\Sigma\ 22B$	$\Sigma\ 19C$	$=$	$\frac{\delta x}{EI}$
$\Sigma\ 36A$	$\Sigma\ 31B$	$\Sigma\ 36B$	$\Sigma\ 19A$	$\Sigma\ 16B$	$\Sigma\ 22C$	$=$	$\frac{\delta y}{EI}$
$\Sigma\ 36C$	$\Sigma\ 36B$	$\Sigma\ 31C$	$\Sigma\ 22A$	$\Sigma\ 19B$	$\Sigma\ 16C$	$=$	$\frac{\delta z}{EI}$
$\Sigma\ 16A$	$\Sigma\ 19A$	$\Sigma\ 22A$	$\Sigma\ 12A$	$\Sigma\ 14A$	$\Sigma\ 14C$	$=$	$\frac{\theta x}{EI}$
$\Sigma\ 22B$	$\Sigma\ 16B$	$\Sigma\ 19B$	$\Sigma\ 14A$	$\Sigma\ 12B$	$\Sigma\ 14B$	$=$	$\frac{\theta y}{EI}$
$\Sigma\ 19C$	$\Sigma\ 22C$	$\Sigma\ 16C$	$\Sigma\ 14C$	$\Sigma\ 14B$	$\Sigma\ 12C$	$=$	$\frac{\theta z}{EI}$

Fig. 7 ... table can be largely filled in from Fig. 6. In the last column are entered the displacements (δ) and rotations (θ) of end (0, 0, 0) relative to end (x_n, y_n, z_n), divided by the flexural stiffness EI.

STRESS AT $x =$, $y =$, $z =$
IN PORTION $r =$

	A	B	C
37	M_x	M_y	M_z
38	$-P_z\,y$	$-P_x\,z$	$-P_y\,x$
39	$P_y\,z$	$P_z\,x$	$P_x\,y$
40	$37 + 38 + 39$	$37 + 38 + 39$	$37 + 38 + 39$
41	$9 \quad 40$	$9 \quad 40$	$9 \quad 40$
42	40^2	40^2	40^2
43	$10B + 10C$	$10C + 10A$	$10A + 10B$
44	$42 \quad 43$	$42 \quad 43$	$42 \quad 43$
45	$9A \quad 9B$	$9B \quad 9C$	$9C \quad 9A$
46	$40A \quad 40B$	$40B \quad 40C$	$40C \quad 40A$
47	$2 \quad 45 \quad 46$	$2 \quad 45 \quad 46$	$2 \quad 45 \quad 46$
48	$9\,P_x$	$9\,P_y$	$9\,P_z$
49	$\Sigma 44 - \Sigma 47$		
50	$\sqrt{49}$		
51	$\Sigma 41$		
52	$\Sigma 48$		
53	$50/Z$		
54	$52/A_t$		
55	$\{\|53\| + \|54\|\}^2$		
56	$51/2z$		
57	$3\{56\}^2$		
58	$55 + 57$		
59	$\sqrt{58}$	←This figure is to be compared with the permissible stress.	

Fig. 8 The maximum stress at any point in the tube is given in line 59 of this table, and can be compared with the permissible stress.

and let the successive kinks in the new tube counted away from this end be at (x_1, y_1, z_1), (x_2, y_2, z_2), etc., with the far end of the tube at (x_n, y_n, z_n) (Fig. 3). That part of the tube between the origin and (x_1, y_1, z_1) we call portion 1, that between (x_1, y_1, z_1) and (x_2, y_2, z_2) portion 2, and so on, portion r being between $(x_{r-1}, y_{r-1}, z_{r-1})$ and (x_r, y_r, z_r). The length of portion r we denote by l_r, and Poisson's ratio by ν.

(*c*) Fill in a sheet similar to that of Fig. 6 for each portion of the tube, to an accuracy of at least seven significant figures. (This does not mean that x_r, etc., need be known to seven significant figures, but that when their values have been decided they must be treated in all subsequent calculation as though they had seven-figure accuracy, e.g., if $x_3 = 96{\cdot}2$, $y_3 = 15{\cdot}3$, $z_3 = 41{\cdot}7$, they must be regarded in calculation as $x_3 = 96{\cdot}20000$, $y_3 = 15{\cdot}30000$, $z_3 = 41{\cdot}70000$.) It will be noted in Fig. 6 that *italic* figures refer to lines and columns of the calculation sheet; the letter denoting the column is omitted when the reference is to the same column as that in which the operation is being carried out. The economic order of completion of the sheet on most calculating machines is lines 1 to 8, l_r^2, l_r, lines 9 to 29, 32, 33, 34, 30, 31, 35 and 36.

(*d*) Total coefficients for all the portions of the tube as in Fig. 7. In the last column of Fig. 7 enter the displacements* δ and rotations θ of end (0, 0, 0) relative to end (x_n, y_n, z_n), divided by the flexural stiffness of the tube (EI). Displacements in the direction of the co-ordinate axes are taken positive, as are clockwise rotations about them (right-hand corkscrew rule).

(*e*) Solve the equations of Fig. 7 by any suitable means, thus obtaining P_x, P_y, P_z, M_x, M_y and M_z.

(*f*) The maximum stress at any point in the tube can now be found by filling in a sheet similar to Fig. 8. It may be noted that *italic* figures and letters again refer to lines and columns of the calculation sheet and that numbers less than 37 are to be found on the corresponding Fig. 7 sheet. Z is the section modulus of the tube and A_t its cross-sectional area. $\Sigma 44$ means $44A + 44B + 44C$, etc., and the use of the sign ‖ in line 55 implies that the positive value is to be taken.

Fig. 9.

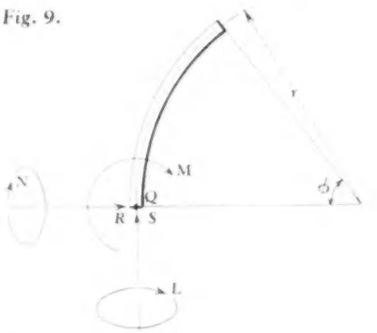
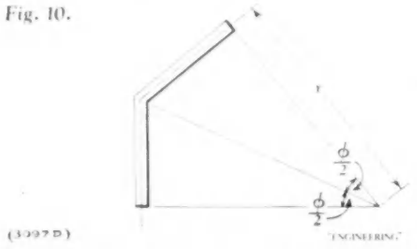


Fig. 10.



Figs. 9 and 10 The tube of Fig. 9 can be replaced by that of Fig. 10 without significant error.

APPENDIX

Errors Involved in Replacing a Circular Pipe Bend by a Kink

Consider a circular pipe bend of angle ϕ and radius r, as shown in Fig. 9, subjected at one end to forces P, Q, R and moments L, M, N. Then, if U is the strain energy of the bend it can be shown with a little algebra that

$$\left.\begin{aligned}
EI\frac{\partial U}{\partial L} &= \frac{Lr}{4}\{(2+\nu)\,2\phi + \nu\sin 2\phi\} \\
&\quad + \frac{Nr}{4}\,\nu\,(1\text{-}\cos 2\phi) \\
&\quad + \frac{Qr^2}{4}\{-(2+\nu)\,2\phi + 4\,(1+\nu)\sin\phi \\
&\qquad - \nu\sin 2\phi\} \\
EI\frac{\partial U}{\partial M} &= Mr\phi + Pr^2(\phi - \sin\phi) \\
&\quad - Rr^2(1-\cos\phi) \\
EI\frac{\partial U}{\partial N} &= \frac{Lr}{4}\,\nu\,(1-\cos 2\phi) + \frac{Nr}{2}\{(2+\nu)\,\phi \\
&\quad - \nu\sin\phi\cos\phi\} + \frac{Qr^2}{4}\{4 + 3\nu \\
&\quad - 4\,(1+\nu)\cos\phi + \nu\cos 2\phi\} \text{ etc.}
\end{aligned}\right\} \quad . \quad . \quad . \quad (16)$$

If we replace the actual circular bend with a kinked one formed by producing the tangents at the ends of the original bend to their point of intersection (Fig. 10), the expressions of equations (16) become modified to

Now let us consider which terms are significant.

$$\left.\begin{aligned}
EI\frac{\partial U}{\partial L} &= Lr\sin\frac{\phi}{2}\left\{2 + \nu\left(1 + \cos^2\frac{\phi}{2}\right)\right\} \\
&\quad + \frac{Nr}{2}\,\nu\sin\frac{\phi}{2}\sin 2\phi \\
&\quad + \frac{Qr^2}{2}\sin^2\frac{\phi}{2}\sin\phi\left\{(1+2\nu)\cos\phi - 2\right\} \\
EI\frac{\partial U}{\partial M} &= 2\,Mr\sin\frac{\phi}{2} + \frac{Pr^2}{2}\sin^2\frac{\phi}{2}\sin\phi \\
&\quad - \frac{Rr^2}{4}(1-\cos\phi)\,(3+\cos\phi) \\
EI\frac{\partial U}{\partial N} &= \frac{Lr}{2}\,\nu\sin\frac{\phi}{2}\sin 2\phi \\
&\quad + Nr\sin\frac{\phi}{2}(2 + \nu\sin^2\phi) \\
&\quad + \frac{Qr^2}{2}\sin^2\frac{\phi}{2}\left\{2\,(1+\cos\phi)\right. \\
&\qquad \left. + (1+2\nu)\sin^2\phi\right\} \text{ etc.}
\end{aligned}\right\} \quad . \quad . \quad . \quad (17)$$

We denote the coefficient of P in $\frac{\partial U}{\partial M}$ by $\overline{PM}$ and the ratio of $\overline{PM}$ with the kinked tube to $\overline{PM}$ with the curved tube by $\overline{PM}\frac{K}{C}$. Assuming that the bends are not too great a proportion of the total length of tube, the displacements due to our applied forces and moments will be relatively unimportant, but angular changes will be significant, since they may produce large displacements far from the bend. We deduce that errors in $\overline{MP}$, $\overline{RP}$, $\overline{PP}$, $\overline{NQ}$, $\overline{LQ}$, $\overline{QQ}$, $\overline{MR}$, $\overline{PR}$ and $\overline{RR}$ do not matter. $\overline{QL}$, $\overline{PM}$, $\overline{RM}$ and $\overline{QN}$ will be unimportant compared with the moment-linked terms unless the bend is near a point of contraflexure; in this case the energy contributions of the bend will be small anyway.

We are left as significant terms with $\overline{LL}$, $\overline{MM}$, $\overline{NN}$, $\overline{LN}$ and $\overline{NL}$. From equations (16) and (17) we have the relationships given in equation 18, on the following page (and plotted for $\nu = 0{\cdot}3$ in Fig. 11).

The first three of these have errors which vary between zero at $\phi = 0$ deg. and 100 $\left(1 - \frac{2\sqrt{2}}{\pi}\right) = 10$ per cent. at $\phi = 90$ deg. The error in $\overline{LN}$, however, reaches 10 per cent. at $\phi = 30$ deg. and 100 per cent. at $\phi = 90$ deg. If we investigate the relative values for the curved bend (equations 16) we find that at $\phi = 90$ deg., $\overline{NL}$ is only $\frac{2\nu}{(2+\nu)\pi}$ of $\overline{LL}$ or $\overline{NN}$ (8 per cent. for $\nu = 0{\cdot}3$); it follows that errors in this term will not be of importance.

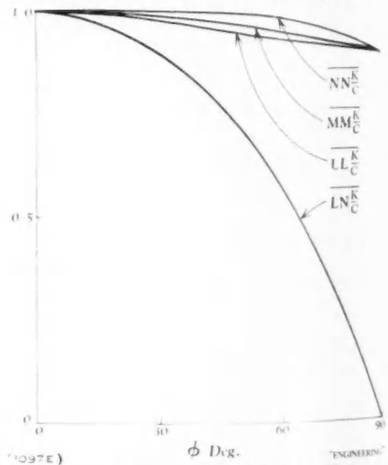


Fig. 11 Values of $\overline{NN}\frac{K}{C}$, $\overline{MM}\frac{K}{C}$, $\overline{LL}\frac{K}{C}$ and $\overline{LN}\frac{K}{C}$ plotted against different values of ϕ. Their derivation is shown in equation 18.

* It should be noted that these displacements are those which are caused by the forces P_x, etc. In the case of a tube encastred at both ends and then heated, they are of the same magnitude as the displacements caused by free thermal expansion, but of opposite sign. The rotations in this case are zero.

$$\left.\begin{aligned}
\overline{LL\,\frac{K}{C}} &= \frac{\sin\frac{\phi}{2}\{2+\nu(1+\cos^2\phi)\}}{2(2+\nu)\phi+\sin 2\phi} \\
\overline{MM\,\frac{K}{C}} &= \frac{\sin\frac{\phi}{2}}{\phi} \\
\overline{NN\,\frac{K}{C}} &= \frac{4\sin\frac{\phi}{2}\{2+\nu\sin^2\phi\}}{2(2+\nu)\phi-\nu\sin 2\phi} \\
\overline{LN\,\frac{K}{C}} &= \frac{\sin\frac{\phi}{2}\sin 2\phi^{*}}{\sin^2\phi} = \overline{NL\,\frac{K}{C}}
\end{aligned}\right\} \quad (18)$$

* Maxwell's reciprocal theorem.

Finally, we conclude that provided the bends do not occupy too high a proportion of the totai length of tube, and provided we always choose $\phi \leqslant 90$ deg., no major error in the stress distribution is likely to arise from replacing the actual circular bends by sharp kinks.

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C.I.G.R.E. 1956

As already announced the sixteenth meeting of the Conférence Internationale des Grands Réseaux Electriques (C.I.G.R.E.) will be held at the Fondation Berthelot, 28 Rue Saint Dominique, Paris, from May 30 to June 9, 1956. In order to reduce the number of simultaneous meetings, and thus to lighten the programme, the Asministrative Council has decided that only groups of papers coming under the general headings of "generation, transformation and cutting off current"; construction, insulation and maintenance of overhead and underground lines; operation, protection and interconnection of networks; and power transmission at over 220 kV will be discussed. Nevertheless, some 130 papers will be dealt with at the meetings (this is about the same as in 1954), while another five, which cover subjects to be discussed in the 1958 programme, will be presented. The reduction in the number of simultaneous meetings will be effected by dealing with the papers in sections. For instance, in the first section nearly 50 papers will be discussed.

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ENGINE TEST TUNNEL FOR LUFTHANSA

A new engine test tunnel for routine maintenance checks has been built at Lufthansa's maintenance base at Hamburg airport. The tunnel has walls 1½ ft. thick, with a further 6 in. thick sound-absorbing lining on the inside of the test chamber. It is 150 ft. long and 22 ft. wide. At both ends of the tunnel, and parallel to its length, are ten walls with rounded ends each 36 ft. long and 1 ft. thick.

Observers can watch the engine under test through the window of a sound-proofed control room in the side of the tunnel. A wall mirror gives them a view of the further side of the engine.

The test rig has been so designed that engines can be fitted and removed in the minimum time, and it is claimed that any existing piston or turbo-propeller engine can be tested. Fuel for the engines is stored in six underground tanks, each with a capacity of 3,400 gallons.

Calculations for the sound-proofing of the tunnel were worked out by the Third Physical Institute, Goettingen, and the construction was carried out by Gruenzweig and Hartmann A.G.

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SOFT-SOLDERING ALUMINIUM ALLOYS

Corrosion Resistant Joints

With the development of a new high-tin soldering compound and a hand tool for its application, by Tiltman Langley, Limited, 70 New Bond-street, London, W.1, it is now possible to produce strong corrosion-resistant soldered joints in aluminium alloys at a temperature of 250 deg. C., using as a heat source a simple electric hot plate.

The hand tool, which is suitable for use with any fluxless solder normally used with aluminium, comprises a guarded refractory brush. After the surface to be tinned has been treated by the usual cleaning techniques, the solder is applied and the surface is lightly brushed with the tool, which provides a light abrasive action, less damaging to the surface than most tools in current use. No flux is used. After tinning, the surfaces to be joined are placed together and a neat fillet of solder is produced by sweeping through the molten solder with the refractory brush.

The Tiltman Langley solder has stood up satisfactorily under tests in humid conditions and in salt spray. After being raised to a soldering temperature of 250 deg. C. for a short time, no appreciable loss of mechanical properties occurs in most aluminium alloys. The shear strength of the soldered joint is 2½ tons per square inch.

PERFORMANCE OF THE SEAMEW

Details of the performance of the Seamew anti-submarine and reconnaissance aircraft, designed and constructed by Short Brothers and Harland Limited, Queen's Island, Belfast, have now been released. The Seamew, it may be recalled, has been designed for rapid economical production and for simplicity in operation. It is going into service with R.A.F. Coastal Command this month and with the Royal Navy later in the year.

The Seamew has the latest "search and strike" radar and electronic equipment. The radar scanner is housed in a bulge under the fuselage and is located to give the best forward view when the aircraft is diving onto a target. The fuselage has been designed to afford maximum protection to the crew when "ditching." The fixed undercarriage legs can be jettisoned and a watertight ditching floor extends the whole length of the fuselage. The undercarriage is specially designed to avoid bounce when landing on carriers in heavy weather or on rough airstrips.

The bomb cell is approximately 14 ft. long, 3 ft. 1 in. wide and 1 ft. 10 in. deep and is fitted with outward opening doors. There is ample space for the stowage of other types of weapon which the purchaser may wish the aircraft to carry. A bomb bay capable of carrying weapons up to 17 ft. long could be provided at the expense of the ASV radar.

Fittings are provided on the underside of each centre-section wing for the external stowage of the lighter types of stores and rocket projectiles. These fittings are located on each side of the undercarriage legs and could be adapted to provide for the carriage of suitable alternative stores.

The type of stores that can be carried comprise depth charges, within the bomb cell; a hoist, located in the fuselage; sonobuoys, on a light series carrier and adaptor in the bomb cell and on the wing; rockets, on the wings; reconnaissance flares or marine markers, on light series carriers in the bomb cell and on the wings; and training indicators—four can be carried on internal light series carriers for attack simulation and/or on external light series carriers for emergency signalling.

Typical combinations of load that can be carried in addition to fuel for about 4½ hours' patrol are as follows: four 280 lb. depth charges, plus six rockets, plus eight a.s. flares, or eight marine markers or eight sonobuoys, 20 sonobuoys or 20 a.s. flares or 20 marine markers or any combination of these plus six rockets, six 275 lb. a.s. bombs plus three rocket projectiles, five 275 lb. a.s. bombs plus six rocket projectiles, five 275 lb. a.s. bombs plus four rocket projectiles plus eight sonobuoys etc.

The overall dimensions of the Seamew are as follows: length, 41 ft.; span, 55 ft.; folded span, 23 ft.; height normal, 13·42 ft.; height, wings folded, 15·75 ft.

Performance figures are quoted in the tables below:

TABLE I.—*Take-off performance of Seamew*

All-up weight, lb.	Take-off speed, knots	Take-off distance, ft.	
		Still air	12-knot wind
14,000	60·7	747	495
13,500	59·1	678	450

TABLE II.—*Climb Performance of Seamew at a Take-off Weight of 14,000 lb.*

Allowance has been made for fuel consumed during the climb.

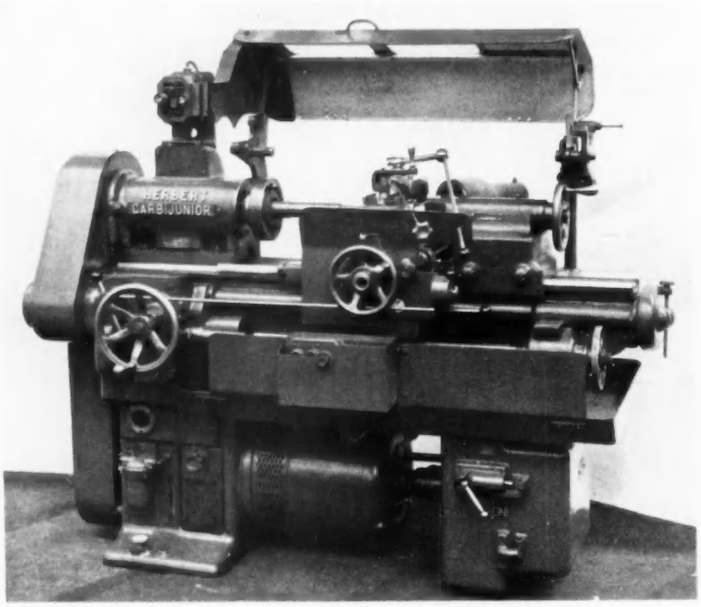
Altitude, ft.	Rate of climb, ft. per min.	Time to height, minutes
Sea level	1,600	—
10,000	750	9·0
20,000	240	32·5

Service ceiling—24,500 ft.

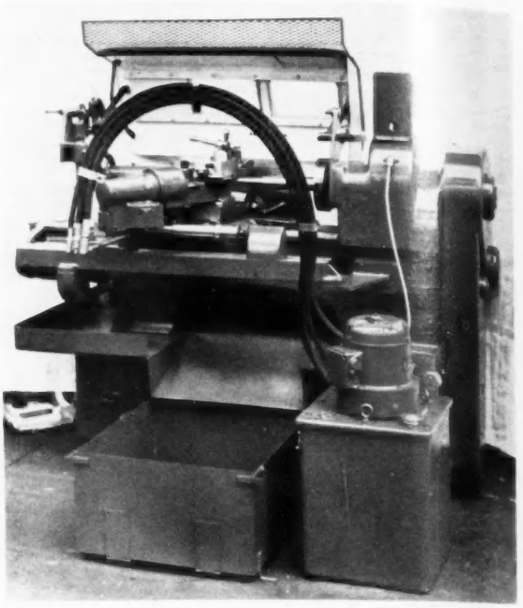
TABLE III.—*Level Speed Performance of Seamew at All-up Weight of 14,000 lb.*

Allowance has been made for the fact that the jet does not act parallel to the line of flight

Engine condition	Altitude, ft.	True airspeed, knots
Emergency rating ..	Sea level	211
	10,000	198
Maximum continuous ..	Sea level	196
	10,000	176



The Herbert "Carbijunior" hydraulic copying lathe has a capacity of 3¼ in. in diameter and 22½ in. between centres. Eighteen speeds are available from a two-speed motor. Hydraulic power is supplied from a separate unit.



The copying unit is hydraulically operated. It is fixed on the saddle and works from a model mounted in the model carrier at the rear of the machine.

SMALL HIGH-SPEED COPY-TURNING LATHE

FREE-HAND TURNING AS ALTERNATIVE

The "Carbijunior" copy-turning lathe introduced by Alfred Herbert, Limited, Coventry, is a development of their "Carbicut" centre lathe. It is also basically a centre lathe and can be used as such for free-hand turning, but it is normally equipped with a hydraulically-operated copying attachment; the machine can, if specially ordered, be supplied without the copying mechanism for use as a simple high-speed lathe. The capacity is 3¼ in. in diameter and 22½ in. between centres.

The machine has a cast-iron bed, case-hardened on the two prismatic guiding ways, and a main spindle running in ball and roller bearings. The drive to the spindle is by V-belts from the driving box in the left-hand cabinet below the bed. Eighteen speeds, from 150 to 3,025 r.p.m., are available by means of pick-off gears and a two-speed motor. Push-button controls mounted on the headstock enable either motor speed to be selected and the motor to be stopped from the normal working position.

A spring-loaded centre is fitted to the main spindle so that a register for length can be obtained from the end-face of the work-piece. Two work-drivers are provided, to accommodate work from ¾ in. to 2¼ in. in diameter and from 2¼ in. to 3¼ in. in diameter respectively. A three-jaw concentric chuck can be supplied as an extra fitting. The tailstock has a live centre of improved type mounted in ball and roller bearings, and the spindle is spring-loaded to allow the work to expand. The saddle has automatic feed towards the headstock in addition to hand motion, a range of three feeds being available. Single-speed quick traverse in either direction is by an independent motor drive.

HYDRAULIC COPYING

The copying mechanism consists of an auxiliary tool-slide, a model carrier, a free-standing hydraulic pump unit and a retraction unit. It will reproduce any turned part which is within the capacity of the machine and of any form which does not involve too high a rate of in-feed.

An auxiliary or copying slide is mounted on the back of the cross-slide in place of the rear tool-post to carry the copy-turning tools. The square turret on the front of the cross-slide is retained in its normal position for undercutting and recessing operations, and for free-hand turning when required. The copying slide consists of two parts, a lower slide fixed at an angle to the centre-line of the machine, and an upper slide which is movable. At the rear of the upper slide is mounted a hydraulic cylinder for moving the slide as determined by a built-in control valve operated by a swinging arm carrying an Ardoloy-tipped stylus. The upper slide also carries a tool-block which is adjustable at right angles to the machine centre-line by means of a fluted handle at the front of the machine. A micrometer dial with setting fingers and a screw-adjusted dead stop are also provided.

The model carrier consists of a long table supported on two brackets at the rear of the machine and parallel with the bed. It has a T-slot along its entire length and carries two brackets with centres which are freely adjustable. The right-hand centre is adjustable lengthways and sideways, the left-hand centre is spring-loaded. An overriding control, the retraction unit, which is operated by a lever from the front of the machine saddle and connected to the tracer valve by a cable, enables the operator to cut out the stylus control at any time and return the copying slide to its fully retracted position.

In operation, the cutting tool follows exactly in the path taken by the stylus, which is traversed along the model by the longitudinal feed of the saddle. Square shoulders, tapers, or any other form which does not involve too high a rate of in-feed are thus produced automatically.

Hydraulic power is supplied by a free-standing unit at the back of the machine. It consists of an oil tank, pump and pump motor standing on the floor and connected to the hydraulic cylinder by flexible oil pipes. The motor is controlled by push buttons mounted at the front of the machine. A spring-balanced chip guard is fitted at the front of the machine. It has an armour-plate observation window, and can be swung clear for access to the spindle and tools. The top and rear of the machine are enclosed in a fixed guard of close-mesh perforated metal. Chip disposal is by means of a chute in the rear of the chip tray, leading to a large bin at the rear of the machine.

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GROUPED ENGINEERING WORKSHOPS AT STOCKSBRIDGE

Steelworks Extensions

Work has now begun on the erection of new grouped engineering workshops at the Stocksbridge Works, near Sheffield, of Samuel Fox and Company, Limited, an associated concern of the United Steel Companies Limited, 17 Westbourne-road, Sheffield, 10. Covering an area of 32,520 sq. ft., and costing about £320,000, the workshops are being erected as near as possible to the centre of the works, in the narrow valley of the Little Don, but outside the production area of the plant. They will provide electrical, joinery, wagon-repair, machining and general engineering services for all production departments at Stocksbridge as well as the company's Rotherfield Works, at Rotherham. These activities, at present, are housed in buildings which, apart from their obsolescence, are in the way of correct production development.

The new shops will consist of three 45 ft. wide bays and a fourth bay 15 ft. in width, on a 340 ft. frontage. Among the main items of equipment to be installed are a 15 ton and four 3 ton electric overhead cranes, ten screw-cutting and self-centring lathes, two shaping machines, a planing machine and two vertical and three horizontal boring machines.

The new workshops are due for completion by this summer, when in addition to general maintenance work, they will contribute to the major £5½ million development schemes now in progress at Stocksbridge. These schemes include a 20 ft. diameter body electric-arc furnace, a highly-mechanised rod and bar rolling mill and a new blooming and billet-finishing rolling mill. All the electrical installations for these schemes will be controlled from the new workshops while the machine shops will assist in the production of the 500 tons of roller tables required for the new bar and rod mill.

Fig. 1 To give the required capacity, 36 single-phase capacitors have been installed in a compound. An overhead counterpoise system gives protection against lightning, and there are also surge diverters connected to each group.

CORRECTING THE POWER FACTOR

INSTALLATION OF 12 MVAr CAPACITY

A problem that has to be faced in most works that use a very large quantity of electricity is that of maintaining a good power factor, not only from the point of view of direct consumption, but also to take advantage of the tariff benefits and avoid the penalties of the suppliers. Such a problem was brought to a head at the Spondon Works, (Derbyshire) of British Celanese Limited by a change in the local tariff and an increase in electricity charges.

In spite of the fact that the load at these works includes 11,000 kVA of synchronous motors excited to run at a power factor of between 0·95 and 0·9 leading, the overall factor was 0·8 lagging—a figure obtained by careful tests. In order to determine this figure (on which calculations for the size of capacitor required were based) a precision power-factor recorder with a short operating range giving a very open scale was installed. This was fed from a current summation system energised by current transformers attached to the main incoming supply at the 33/6·6 kV transformers. The recorder is still in use, and gives a continuous record of the overall power factor for the works. From the figure of 0·8, it was estimated that a total capacity of 12 MVAr would be required to bring the power factor up to 0·97 lagging. In view of the fact that the load factor of the works is at least 90 per cent., it was decided that automatic control would be unnecessary. This decision was amplified because the value of the lagging MVAr corresponding to minimum load conditions would be greater than the leading MVAr associated with the capacitors.

SITING THE CAPACITORS

The electricity supply for the works is obtained from the Spondon power station of the Central Electricity Authority, which is directly adjoining. The supply comes to the works main substation where it is reduced from 33 kV to 6·6 kV by 15 MVA transformers. These are of the high-reactance type and reduce the fault-power level on the company's high-tension distribution network to approximately one fifth of that of the Authority's network on the primary side of the transformers. The transformers are fitted with off-load tap changers, and feed a number of local substations distributed over the works.

Ideally, the capacitors required to raise the power factor should be installed on the low-tension network in the various parts of the plant, but this was not advisable as large areas of the works require flame-proof installations; also space limitation in the factory substations would have necessitated considerable additional building. The installation of capacitors in the factory substations on the high-tension side was also not advisable, as the switchgear is of the duplicate busbar type and therefore such an installation would be of a high cost. Moreover, as mentioned before, considerable building extensions would be required, particularly as these substations are two-storey buildings. It was therefore decided that the capacitors should be designed for use on the high-tension system but that with their associated switchgear they should form a completely separate installation.

In order to give the greatest possible flexibility together with immunity from phase faults, and to permit a monitoring system to be used, it was decided that the capacitor installation should comprise 36 single-phase units. These have been made by Johnson and Phillips, Limited, Charlton, London, S.E.7, and have a voltage range of from 3·81 to 4·15 kV corresponding to a system voltage of 6·6 to 7·2 kV. The corresponding outputs are from 333 to 400 kVAr. This range of working voltage was necessary to allow for the maximum voltage regulation on the system, and the units are suitable for continuous working on the upper voltage limit. The capacitors are of the paper dielectric type, oil impregnated, oil immersed and fitted with internal fuses and discharge reactors. The tanks are sealed for use outdoors and are made of boiler-plate with cooling fins; each capacitor is fitted with a cable box and outdoor type porcelain bushes. In order to give a corrosion resistant finish the external surfaces of all tanks have been shot-blasted and sprayed with aluminium before being painted. The whole of the high-voltage switchgear is of the air-insulated type, and all items have been submitted to full-scale switching tests at the makers' works to prove their suitability for the control of purely capacitance reactive loads.

The installation was designed in two electrically identical halves each of 6 MVAr capacity, and provision has been made for each half to be extended to 10 MVAr. The circuit diagram of one half is given in Fig. 3. All the switchgear has been made by Crompton Parkinson Limited, Chelmsford.

CONNECTIONS AND PROTECTION

Two duplicate busbar air-insulated, 1,200 ampere 350 MVA circuit-breakers were installed in the main incoming sub-station. Each of these feeds two four-panel single-busbar vertical-isolation 250 MVA boards, by two 0·5 sq. in. 3 core cables in parallel. Each of the boards has one 1,200 ampere type ALA3 incoming circuit-breaker and three 400 ampere ALA2 outgoing breakers. In order to facilitate isolation in the event of a fault occurring on any of the 0·5 sq. in cables, two independent sets of 600 ampere cable isolators with earthing positions were installed on each of the 350 MVA equipments, and removable cable links have been provided at each of the ALA3 incoming breakers.

Each of the ALA2/3 switchboards is remote controlled from a four-panel control board. The switchgear control boards and fault making isolators are installed in a new single storey switch house. The ALA2 outgoing breakers each feed a pair of 250 MVA 400 ampere ALA1 fault making load breaking isolators. Two pairs are shown in Fig. 2. Each of the ALA isolators has three ammeters and a cable box from which three single core P.I.L.C.S. cables lead to three 333 MVAr capacitors. The 36 capacitors are installed on a common base plinth measuring 125 ft. × 25 ft., divided by brick fire-barrier walls into six bays. The capacitor installation is shown as a whole in Fig. 1 and one of the cable runs in Fig. 4. All the cables used were supplied by W. T. Henley's Telegraph Works Company,

Fig. 2 Fault-making load-breaking isolators feed the separate capacitors from the distribution switch-board. The Castell keys normally trapped in these isolators are required to open the gates of the compound.

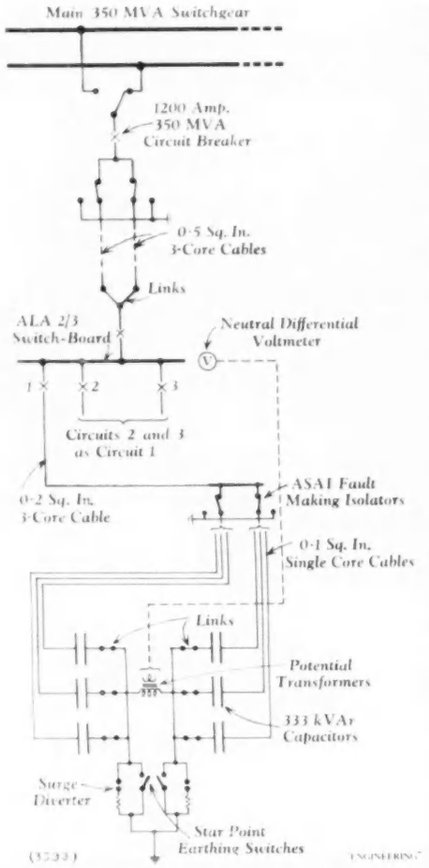

Fig. 3 The system is composed of two electrically identical halves, one of which is shown here.

Limited, 51/53 Hatton-garden, London, E.C.1.

The three capacitors installed on each side of the plinth in each bay are controlled by one of a pair of ASA1 isolators. Each group of three capacitors is star-connected at the external bushings, and an outdoor-type single-phase potential transformer is connected between the star points of the two groups of three installed in each bay. The function of this potential transformer is to give an indication of the voltage of the floating neutral star point of each bank of three with respect to the star point of the other bank in the same bay. This gives visual monitoring of the performance of the capacitors. Under healthy conditions the voltmeters give a zero indication, but should a reading be observed it is a simple matter to ascertain which is the faulty unit by reference to the individual ammeters. The unit can then be disconnected by the link provided. To disconnect the capacitors in the event of an interruption of the supply to the works, and to safeguard against the simultaneous re-energising of the whole bank when the supply is re-established, each ALA switchboard is equipped with under-voltage, time delay and multi-contact tripping relays. The undervoltage relay is set to operate at 40 per cent. of the normal voltage, and energises the time delay relay which has a lag of six seconds. At the expiration of this period the tripping relay is energised, and the associated switches are tripped out. The time delay of six seconds gives a margin to prevent the protective system operating due to a transient depression of the voltage as a result of system faults.

Two methods are employed to protect the high-voltage cable network and its associated equipment from the effect of lightning. The first consists of an overhead counterpoise system, and the second the fitting of surge diverters, of the silicon-carbide type, between the neutral point of each group of capacitors and earth. The surge diverters have a residual voltage characteristic of 35 kV which allows a good safety margin for the cables, switchgear and other equipment to withstand normal surges. A neutral earthing isolator is connected in parallel with each surge diverter. These are used to earth the equipment when personnel are working in the bay.

Each bay of the compound has a gate which requires two different Castell keys to be inserted before it can be opened. These two keys are trapped, one in each switch of the respective pairs of ASA1 isolators. The keys cannot be released until the isolators are opened and earthed, and the isolators cannot then be closed until the keys are replaced. Similarly, the keys can only be removed from the gate after it has been closed and locked.

In order to contain the oil in the event of a burst of one of the capacitor tanks, each bay of the compound has low brick containing walls and a pebble-filled draining trench. The trenches are piped to a pebble-filled sump, which has a separate compartment with a submersible pump installed. The pump has automatic level control and discharges to a remote soakaway pit. Under normal conditions the pump removes rain water drained from the compound, and so ensures that there is always sufficient capacity in the sump to accommodate the oil content of one capacitor.

In order to give remote indication and recording of the total MVA demand of the factory, and also the power factor of the load, electronic transmitting and computing equipment has been installed at the main incoming substation. This feeds receiving instruments at the main observation points in the works.

The observed power factor of the factory load with the equipment in service is between 0·98 and 0·99 lagging, and approaches 1·00 when the works is running on base load, as, for example, at night. The improvement in performance of the installation as compared with the design value of 0·97 is due to the reduction of the voltage regulation of the main high-reactance transformers consequent upon the raising of the load power factor and its effect of increasing the charging current of the capacitor bank. This increase is approximately 8 per cent. of the value corresponding to that of a nominal system voltage of 6·6 kV.

The site chosen for the erection of the new switch house and the capacitor compound is one that was occupied by a redundant double-track railway embankment, of which 230 ft. had to be removed. The time from the start of removal of the embankment to the commissioning of the complete project was 7½ months. With a view to reducing maintenance costs to a minimum, the supporting steelwork for the insulators was given a Jenolite treatment prior to painting, and Duralumin has been extensively used for all other outdoor structural supports. The installation, which is believed to be the largest of its kind in this country, was designed by the company's Chief Electrical Engineer, Mr. A. Berman, M.I.E.E., and was erected under his supervision and by his staff.

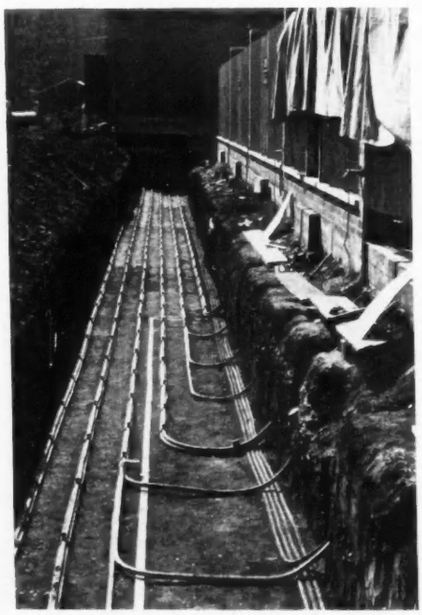

Fig. 4 Single-core cables, braided in trefoil, connect the isolators to the capacitors.

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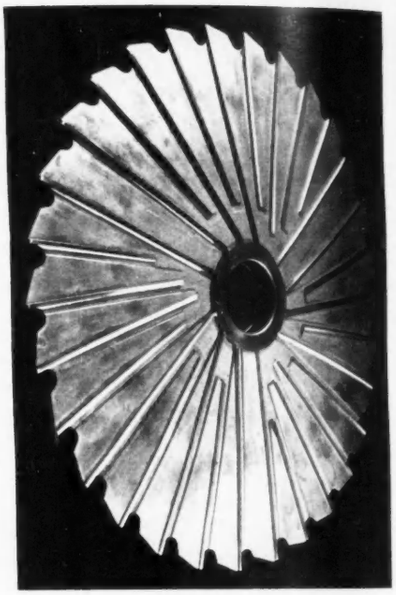


Side view showing cutting edges of the milling cutters, nearly 15 in. in diameter, made for machining aircraft components.

LARGE PRECISION MILLING CUTTERS

6 in. Depth of Cut

Large milling-cutter gangs for machining high-tensile steel aircraft components are being supplied by English Steel Tool Corporation Limited, Manchester, to Vickers-Armstrongs (Aircraft) Limited, Supermarine Works, Swindon. One of the gangs consists of two 15·200 in. diameter single-angle cutters and three 14·952 in. diameter double equal-angle cutters. Though not the largest cutters made by the company, they are among the largest solid H.S.S. cutters of this type made in Great Britain. The important features of this gang are the angle of taper, the width of the cutters and the steps between the cutter diameters, all of which have to be controlled to exceedingly fine limits, a task made difficult by the fact that the double equal-angle cutters are of a rather slender section, tapering from 1·050 in. wide to a tip radius of 0·18 in.

At the design stage it was decided that, as the bulk of the material would be removed by the tip radius, it was necessary to provide at that point a positive cutting rake which, when continued down the sides of the cutter, would supply the side teeth with the necessary shearing action, the depth of the cut being approximately 6 in. Moreover, to give all the teeth a positive rake would have made an already awkward proposition extremely difficult, so it was decided to make three equally spaced teeth radial, that is, with no rake. This accounts for the uneven spacing and lengths of the teeth towards the centre of the cutter, as can be discerned in the illustration above.

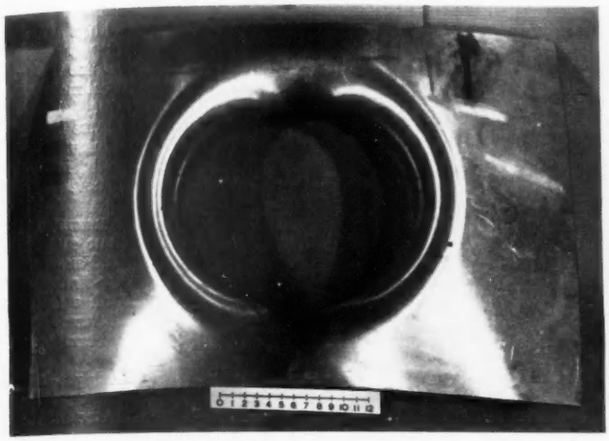


Fig. 1. A ½ in. thick re-entrant diaphragm produced on a 4,000 ton rubber bolster press.

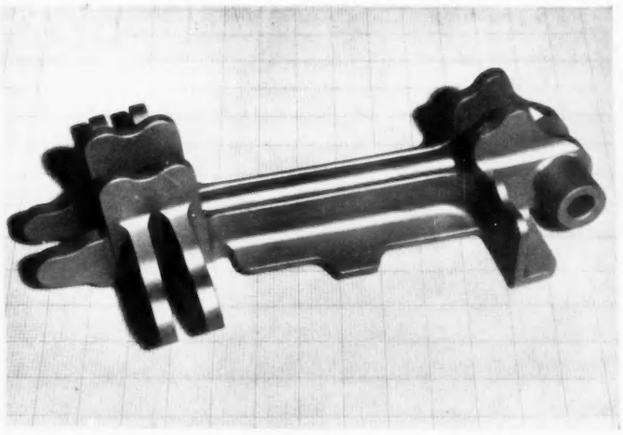


Fig. 2 High-tensile steel investment casting used instead of a forging for wing-attachment fitting.

PROCESSES, QUALITY CONTROL AND CUTTING RESEARCH

SPEEDING AIRCRAFT PRODUCTION

The fourth conference on "Problems of Aircraft Production" organised by the Institution of Production Engineers and held at the University of Southampton on January 6 and 7 was based on the theme of "Speeding Aircraft Production"—by improved organisation and production techniques, by new methods of quality control, and by improving machining processes on the basis of research into the factors effecting the life of and effectiveness of cutting tools. This conference was notable in providing the occasion of the Institution's first Lord Sempill paper, delivered by Sir Roy Fedden, on "Britain's Aircraft Needs." Three other papers were discussed at the conference—"Time can be Saved in the Aircraft Industry," by Mr. H. G. Gregory and Mr. A. Vines, of the Fairey Aviation Company, Limited; "Control of Production Processes," by Mr. I. R. Smith, chief inspector of the Aircraft Division of the Bristol Aeroplane Company, Limited; and "Machining Research and its Impact on Speeding Production," by Mr. D. A. Oliver, Mr. T. S. Lister, Mr. M. D. Kinman, and Dr. D. Fitzgeorge, of B.S.A. Tools Limited. This last paper was sponsored by the Machine Tool Trades Association.

SHOCK TREATMENT FOR THE AIRCRAFT INDUSTRY

With less than 600 swept-wing fighters and less than 50 V-bombers in service, the air strength of Great Britain had never before fallen so far below the country's needs; and the reason for this was indecision and faulty judgment on the part of the Government departments concerned and the leaders of the aircraft industry. These were the views which Sir Roy Fedden expressed in his paper on "Britain's Aircraft Needs."

In what he described as "a little shock treatment," Sir Roy showed that during the 10 post-war years neither the Government nor the industry had appreciated the scale of the technical resources that would be required to realise the vast opportunities opening up. For the time being, he said, we had lost the courageous leadership and the burning spirit to succeed at all costs. The Royal Aeronautical Society and the Society of British Aircraft Constructors, the instrument manufacturers and the tool makers, had all to some degree failed in initiative and in facing facts; and in Sir Roy's estimation, some 75 per cent. of all engaged in the aircraft industry were failing to pull their weight.

There was hope, however, because the industry still had a trained nucleus of disciplined engineers with unbeatable creative capacity. Sir Roy's solution to the sickness that beset the industry was to concentrate effort over a smaller range of objectives; to pursue the possibilities of automatic electronic control for machine tools with the utmost vigour, because by so doing small-batch production could be carried out with the minimum of tooling, and high accuracy; and, above all, to expedite the training of many more engineers and to raise the status of the engineer in popular opinion and with all urgency.

Possibly the principal point which emerged during the discussion on Sir Roy's provocative paper was that not only the aircraft industry but the whole country was in need of a dose of "shock treatment," while several speakers thought that Sir Roy had over-stated the degree of slackness prevalent in the aircraft industry. It was suggested that the present trend in education was too much towards "science," and away from practical engineering. A particular point made was the allocation of junior draughtsmen to the design of details who had insufficient grasp of the way things were made, with the result that tool makers were often called upon to produce tools for impractical and often absurd designs. Greater uniformity in the firms' tooling demands, it was suggested, would simplify the lot of the contract tool maker.

In defence of the machine-tool manufacturers, it was pointed out that the United States Government had offered unlimited funds for the development of prototypes, and it was suggested that had the same policy been adopted in the United Kingdom, the British tool industry would not have been found wanting. It was, on the whole, agreed that there ought to be closer co-operation between Great Britain and the United States, as regards the rationalisation of aircraft and weapons to be produced by both countries; and that Great Britain should not be too proud to profit from the manufacturing experience of the United States.

A variety of ways in which the Fairey Aviation Company, Limited have speeded up aircraft production were described in the paper entitled "Time can be Saved in the Aircraft Industry," by Mr. H. G. Gregory and Mr. A. Vines. In the first part of the paper, presented by Mr. Vines, the speaker commenced with a plea for steady quantity production in the aircraft industry which, he said, could be achieved if the nation realised the vast potentialities of air cargo transport.

ORGANISATION

Mr. Vines then described their works organisation. The design office was divided into groups by types of aircraft, and a production development section worked closely with the design team. By this means the assembly and interchangeability aspects of design were studied from the start of a project. Each department

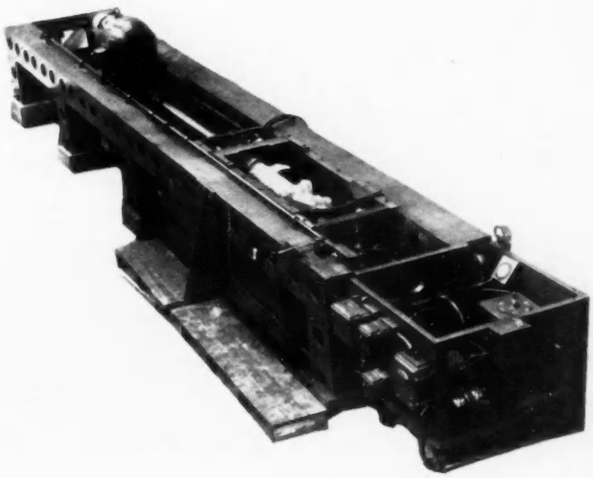


Fig. 3 Trepan boring machine for oleo-leg outer casing. The bored hole is 4¼ in. in diameter by 45 in. long; the slug diameter is 2¾ in.

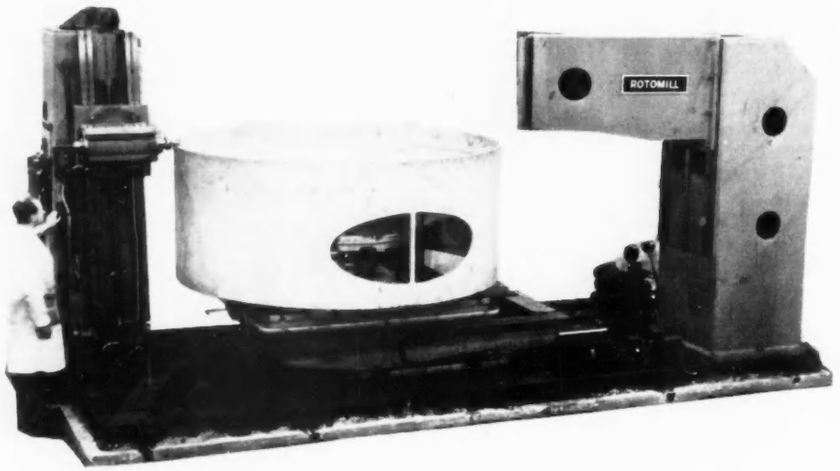


Fig. 4 The Rotomill carries two high-speed heads mounted vertically and horizontally on each side of a rotating table. The work table, which can be traversed, is fitted with an infinitely variable speed gear.

building a component or group of components was self-contained with its own stores and progress, inspection, planning and ratefixing, and shop supervision. This led to the maximum interest and individual responsibilities for all members of the team.

Mr. Vines then turned to assembly methods, describing the Fairey envelope jigging system and the way the jigs were built up. In this system, which was described in the December 30, 1949, issue of ENGINEERING (vol. 168, page 699), the outer skin was located on the jig and the structure was built up inwards from the skin. By this means, Mr. Vines said, a higher standard of mechanical and aerodynamic interchangeability had been achieved than had been thought possible.

At this stage, Mr. Gregory took over from Mr. Vines, and described some of the time-saving techniques used in the Fairey works. He demonstrated a number of large pressings made on a standard 4,000 ton rubber bolster press, including the re-entrant diaphragm shown in Fig. 1, which was produced from a $\frac{1}{4}$ in. thick blank of AW3 material measuring 4 ft. by 3 ft. with a 19 in. diameter hole routed before pressing. The pressing was formed on a concrete block, with the rubber being used as punch. He also showed examples of high-tensile steel investment castings, used instead of forgings for wing-attachment fittings (Fig. 2) and catapult hooks, which had effected enormous savings in machining operations.

SPECIAL-PURPOSE TOOLS

Mr. Gregory then described a number of special-purpose machine tools developed by the Fairey company, among which were the trepan boring machine for machining oleo-leg outer casings illustrated in Fig. 3.

This machine consisted basically of two 24 ft. long standard jig castings, on which were mounted nitrided slides for the boring carriage, and a clamping unit of the oleo outer cylinder component.

The carriage was traversed by a hydraulic jack to provide infinitely variable feeds, and had a swarf and lubricant outlet at the base. The carriage mounted a 15 h.p. 900 r.p.m. motor, which drove the trepanning tube and lay shaft through V-belts at 700 r.p.m.

The clamping unit carried two locating cones, which were closed by three 2 ton hydraulic jacks, and also the trepanning tube bearing, with high-pressure coolant supply chamber.

The shape of the chip breaker on the carbide tipped tool was important, particularly when cutting DTD.683 in the "as forged" condition, a material which tended to produce large built-up chips. High-pressure lubricant was essential.

The peripheral speed was 780 ft. per minute. The bored hole was $4\frac{1}{4}$ in. in diameter by 45 in. long; the diameter of slug, $2\frac{3}{4}$ in.; the feed, 3 in. per minute; and the floor-to-floor time, 25 minutes.

The Rotomill illustrated in Fig. 4 was designed to carry two high-performance heads, one horizontal and the other vertical, on columns each side of a rotating table. The work table, which could be traversed, was fitted with an infinitely variable speed drive. With high cutting speeds the finish obtained and the time saved was outstanding compared with a standard 10 ft. borer.

CUTTING SPEED 12,000 FT. PER MIN.

Discussing research carried out on high speed machining for integral construction, Mr. Gregory said that cutting speeds up to 12,000 ft. per minute had been achieved with spiral carbide cutters, using oil mist lubrication directed through the hollow spindle of the milling head on to the face of the cutter. Cutting efficiencies of 4 to 7 cub. in. per h.p. per minute had been obtained, the most efficient cutters being of the face-mill type with high rake angles.

The chassis rib of the Gannet, of integrally stiffened construction, was milled by a vertical-column milling machine (Fig. 5) of Fairey design with a hydraulic copying system and two high-speed milling heads rated at 10/20 h.p. at 3,000/6,000 r.p.m. incorporating sprung pre-loaded bearings. The capacity of the machine was 6 ft. longitudinal traverse by 2 ft. vertical movement. Swarf was removed by conveyor belt. The speed of the longitudinal traverse was infinitely variable between 0 and 80 in. per minute. Two ribs were machined simultaneously in about 4 hours; 115 lb. of metal being removed from a 205 lb. slab.

In conclusion, Mr. Gregory enumerated the advantages of automatic programme control of machine tools, and revealed that Fairey were shortly to manufacture a three-dimensional programme-controlled machine with a longitudinal traverse of 25 ft., a vertical traverse of 7 ft. and a cross traverse of 12 in. The Ferranti control system would be employed.

The discussion which followed this paper was severely limited by lack of time. The principal point which emerged was that, with the adoption of the small closely integrated group system as in the Fairey organisation, the interest and morale of all concerned were found to increase. It was agreed that there were advantages in manufacturing one's own machine tools, in that it was possible to provide exactly what was required when it was wanted, where it would be unreasonable to expect the machine-tool industry to provide a special-purpose tool with limited future applications. Nevertheless it was felt that the machine-tool industry should be alive to the possibility that some of these special-purpose tools might lead to big developments.

QUALITY CONTROL

That judicious and efficient control of production processes could prevent waste of materials, labour and time was the conclusion drawn by Mr. I. R. Smith in his paper "Control of Production Processes" in which he discussed the control of materials, manufacture, special processes and current developments and future techniques for quality control. Mr. Smith placed particular emphasis on the necessity for care in handling and storing sensitive high-strength alloys, about the behaviour of which there was still much unknown.

Discussing the control of manufacture, Mr. Smith took as examples the control of heat treatment and the control of welding. In heat treatment, control was exercised both by rigorous control of the bath temperatures and by checks on the chemical and mechanical properties of a test piece from each batch of material undergoing treatment. In welding the emphasis of control had to be directed to the operators, the materials, the equipment and techniques, supplemented by non-destructive testing.

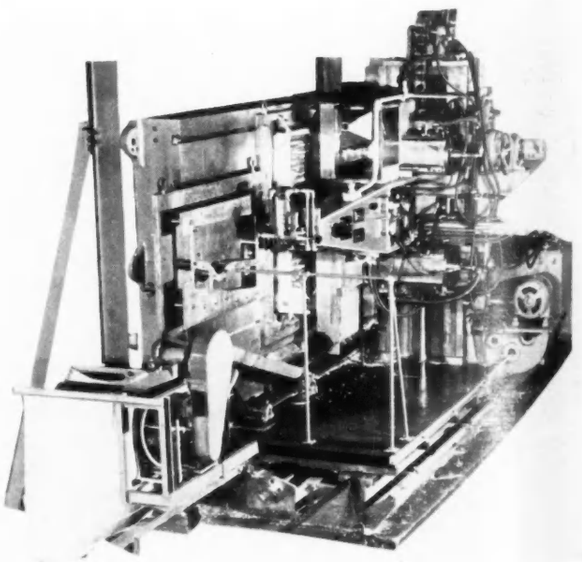


Fig. 5 Vertical-column copy milling machine. The Fairey Aviation Company have found it convenient to have special-purpose machines of this kind made to their own design. It embodies a hydraulic copying system and two high-speed milling heads.

Discussion on the control of special processes, Mr. Smith cited metal-to-metal adhesives and plastics. Satisfactory metal-to-metal-bonded joints required a good fit of the parts to be bonded, and cleanliness of parts before applying the glue. With these two requirements satisfied, the dominant factors were time, temperature and pressure. The peel test had been used as a control of this process, but the Bristol Aeroplane Company had found such a wide scatter in peel strength that they discontinued this test and relied entirely on shear-strength specimens.

Current developments in control techniques comprised the use of dye penetrants for the detection of surface defects, ultrasonics for the detection of sub-surface defects and X-rays for the examination of structures. In discussing future possibilities Mr. Smith drew largely from his observations on a recent visit to the United States.

In America, ultrasonics were playing an increasingly important part in the quality control of raw materials and finished parts. Advances in the design of the electronic equipment there were much greater than in this country, as evidenced by the development of lithium-sulphate crystal, which had proved to be far superior to quartz or barium titanate; and by the technique of immersion scanning, in which it was possible to orientate the crystal in relation to the defect and obtain maximum echo response from the flaw. In all instances ultrasonic inspection was applied by comparing signals obtained on test blocks having known flaws with signals from possible flaws in the material. In the Douglas plant a 90 per cent. accuracy had been obtained in the detection of flaws in large plates and forgings. For surface flaw-detection in non-ferrous metals, the fluorescent penetrant process was considered to be the most efficient method available.

Application of industrial X-rays in the United States was on a similar scale to that employed in the United Kingdom but the Douglas Aircraft Company had successfully applied X-ray techniques to inspection of complete aircraft structures where known defects had arisen. Again this process could only be applied on a comparative basis; it was in an early stage of development but showed considerable promise of saving man-hours. The use of fluorescent screen X-ray equipment, which the Douglas company were using in their "goods received" area, showed promise for the stock inspection of sealed items, castings, etc.

In the discussion which followed Mr. Smith's paper, it was apparent that a number of speakers were hazy as to the exact nature of the inspector's function, which should be solely to ensure that manufactured parts complied with the requirements laid down by the designer. Among the more interesting points that arose was the fact that radio-isotope inspection techniques were now being used by British European Airways in their maintenance routines; that ultrasonic inspection techniques were very extensively used by British manufacturers of high-quality steels and that British steels were much more closely specified than in the United States where, accordingly, quality control by the aircraft manufacturer assumed greater importance. In general, however, inspection standards and methods were very similar on both sides of the Atlantic.

MACHINING RESEARCH

Organised machining research has really only come into being in Great Britain since the end of the second World War, and is still carried on only on a comparatively small scale. However, the Mechanical Engineering Research Board are now sponsoring the advancement of knowledge of the machining process; work of high quality has already been carried out and momentum is gathering. Valuable data has been gathered on the design and operation of small tools, on machine-tool design, and on the cutting fluids used. Four members of the research team of B.S.A. Tools, Limited—Mr. D. A. Oliver, Mr. T. S. Lister, Mr. M. D. Kinman and Dr. D. Fitzgeorge—described some of these advances in a paper entitled "Machining Research and its Impact on Speeding Production."

After outlining some of the fundamental work carried out on the analysis of chip formation, the authors turned to the special problems of the aircraft industry and, after considering the current aluminium alloys and the steels and titanium alloys of the near future, they discussed the influence of the machine tool on milling operations, this being the type of operation of most interest to airframe producers. Extracts from this part of the paper will be found in the article below. In tests on titanium alloy (130 AM alloy, with 4 per cent. aluminium, 4 per cent. manganese) the authors found that much heat was generated during cutting, and that copious cooling was required. No special tools were necessary but for satisfactory results there was a close relation between speed and feed. There was some difficulty in drilling small holes, but it was feasible with modified drills, provided that the holes were not too deep, and that a suitable high-grade soluble oil with extreme-pressure additive was employed. If an unsuitable oil were used, violent fluctuation of the drill torque resulted. Tapping was not very successful.

In machining high tensile steel and other difficult materials, close control of machining conditions was essential—a slight departure would render the operation uneconomic, troublesome or impossible. A greater choice of speeds and feeds on machines would therefore be required; for some operations, such as facing, steplessly variable automatically controlled speeds would be necessary. Above all there must be rigidity and freedom from backlash in tables and spindle drives.

In conclusion, the authors said that they had the impression that the aircraft industry was not sure of what it wanted. The industry should be encouraged to purchase prototype tools and to co-ordinate needs in other fields so as to ensure the appropriate technical assistance from other industries.

The maintenance of cutting tools was one of the points dealt with in the discussion which followed. A surface finish of from 3 to 5 micro-inches was suggested as reasonable for carbide centres, and either metal-bonded or Bakelite-bonded grinding wheels could be used—the former being more resistant to abuse but the latter offering a faster rate of carbide removal. A copious supply of mist coolant was necessary. Honing after grinding was beneficial to the life of high-speed steel tools.

In answer to an inquiry on the drilling, reaming and tapping of high-strength steels, it appeared that whereas drilling and reaming presented no problems, tapping was at present a formidable proposition but the tool manufacturers were endeavouring to find a solution. The development of end mills with high rake angles was a subject requiring further study; it was not yet known whether it would be possible to achieve sufficiently strong tips. If not, and it was necessary therefore to use lower rate angles, much lower cutting speeds would have to be used, with suitable active lubricants.

CERAMIC TOOLS

A query was raised on the development of ceramic tools. In the days when there was a shortage of tungsten, B.S.A. carried out some promising work in ceramic tools, but they were not perfected for production. Their advantage was a wear resistance four times that of tungsten carbide, provided that chipping could be avoided. There were problems in the fixing of ceramic tools. It was possible that they might be revived for the machining of graphite—a very fierce material to cut—for atomic energy and other special applications.

Among other points raised was the suggestion that the time had come for the formation of a group representing the machine-tool trades, the aircraft industry, the steelmakers, and the Ministry of Supply, to discuss and define what were the most important interests of the aircraft industry as a whole.

The conference was brought to its close with a brief speech by Lord Sempill; deploring the lack of adequate time for discussion of the papers, he made a suggestion—which might well be adopted by certain other institutions and learned societies—that no papers should be read at the conference; that they should be prepared some four to six weeks in advance, and very briefly summarised at the conference, leaving ample time for a full discussion.

METAL CUTTING OPERATIONS

INFLUENCE OF THE MACHINE TOOL

We give below extracts from a paper entitled "Machining Research and its Impact on Speeding Production," which was presented by Mr. D. A. Oliver, Mr. T. S. Lister, Mr. M. D. Kinman, and Dr. D. Fitzgeorge, of B.S.A. Tools Limited, at the recent conference on aircraft production held at Southampton. A report on the conference immediately precedes this article.

In America in the late 'thirties, the development of a quick-stopping technique opened up a new field of study in the mechanics of chip formation, which has provided a clear picture of the cutting process. However, it would appear that there is a decline in interest in this branch of the subject in favour of a more practical study of the factors giving better tool-life, and better surface finish.

Chip and tool temperatures are important in connection with tool-life, since the exposure of the tool tip to excessive temperatures will lead to softening and rapid wear. The high temperatures are the result of metal deformation at the shear plane and friction at the face and flank of the tool. Estimates based on the energy input and the physical constants of the work-piece material suggest that the chip will reach a maximum temperature of about 500 deg. C. At high cutting speeds, almost all the heat remains in the chip and it is argued that variations in cutting speed will not affect the temperature appreciably, since the higher speed will result in a greater amount of energy being supplied to a proportionately longer chip in a given time. An increased feed, however, will require a reduction in cutting speed for the same tool life.

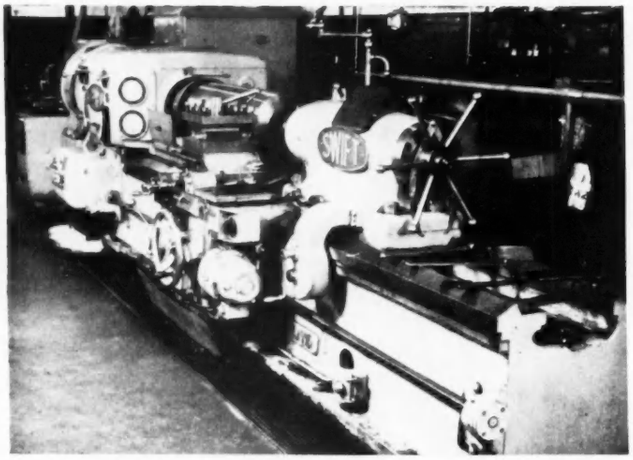
For a given life of the tool, a low cutting speed, a large feed and a large depth of cut will give the best material removal rates, but practical limits exist in the power available, the strength and stiffness of the machine, the tool and the workpiece and the quality of the resulting surface finish.

For machining steels of medium tensile strength particularly with high-speed tools, a good quality soluble oil is generally adequate as a cutting lubricant. As the tonnage of the steel increases, or alternatively, additional elements which increase the work-hardening properties of the material are added, more effective cutting lubricants should be used. A stage is reached when a cutting lubricant with the activity carefully balanced to meet the needs of the job is absolutely necessary to enable the material to be machined at all, regardless of any question of a higher rate of production.

Any study of the machining properties of a material must be accompanied by a full investigation of its more fundamental metallurgical characteristics—microstructure, chemical composition, and thermal history.

RIGIDITY ESSENTIAL

When cutting tools are put to severe use in milling machines, either by machining difficult materials or by high metal removal rates, tool-life



Tests on high-speed steel cutters were carried out on this 75 h.p. Swift lathe, which has an infinitely variable speed range from 17 to 2,000 r.p.m.

is very much dependent on the design and condition of the machine used. This is particularly noticeable with carbide tools on intermittent cutting of high tensile steels. Best results are obtained on conventional machines when working at a fraction of full capacity.

If such a machine is worked to its full capacity, tool-life may be very short, even though external appearances suggest a satisfactory cutting operation free from chatter. Poor tool-life under such conditions is frequently attributed to poor quality cutting tools, when the actual cause lies in the machine. Transferring the job and the cutter to a larger machine in such a case will invariably lead to better cutter performance.

The present authors would emphasise that machine deflections, as well as causing inaccuracy and poor finish, also account for poor tool-life—a fact which is insufficiently well known.

Knee-type millers are inferior to those in which the table is supported by a long fixed bed. In cases where the knee-type construction must be retained, then there should be a substantial increase in the length and spacing of the vertical and transverse slide ways to increase work-table stability.

Cutter arbors and arbor supports are a weak point in conventional milling-machine design and lead to intolerable deflections when cutting tough materials. Arbor diameters should be increased and arbor lengths effectively reduced, wherever possible. The cantilever principle for arbor supports, while making for easy manipulation, is basically unsound and should be abandoned in favour of more rigid designs. It would be an improvement if the keyway in the arbor shaft could be eliminated and replaced by some other method of locking the cutter. The keyway destroys the rotational symmetry of the arbor and varies the cutter deflection according to its angular position, causing a periodic chatter and surface markings. Bearing deflections contribute to the deflection at the cutter. Bearings should be free from clearance at all working speeds. They should be of the ball or roller type and pre-loading is essential.

Increased attention should be paid to the design and lubrication of the feed mechanism and slideways to promote smooth action. Backlash eliminators, particularly in the table feed, should be improved since they are sometimes the cause of chatter when climb-milling.

In some cases it may be advantageous to employ spheroidal graphite cast iron or steel in place of the more usual grey cast iron, even though this will sacrifice some damping capacity. The advantage is in the higher elastic modulus of these materials.

CUTTING HIGH-TENSILE STEELS

In recent tests on alloy steel billets heat-treated to tensile strengths of 100 and 95 tons per square inch, when using carbide face mills with a cutting speed of 140 f.p.m. and a feed per tooth of 0·004 to 0·005 in., a satisfactory tool life could be obtained provided the work-piece and cutter were rigidly mounted. Tool geometry is important. It is essential that the cutting edge is a straight line to allow the chip to curl easily. There should be no radius or chamfer at the nose, and the resulting sharp corner should be rendered less acute by a substantial approach angle (40 deg. to 45 deg.). The best results have been obtained with positive maximum rake angle. The cutting edge is inclined, however, to increase the rake in a radial, and decrease it in an axial, direction.

No success has been achieved with up-milling using carbide-tipped cutters on these high tensile steels.

The authors have recently briefly investigated the effects of machine and set-up stability on carbide-tipped cutter performance. It was found that an 8 in. diameter face mill which had given a satisfactory performance when mounted directly on to the spindle nose of a horizontal milling machine, gave a poor performance when mounted on a 2 in. diameter arbor on the same machine. It is interesting to note that this early failure of the arbor-mounted cutter was not accompanied by any observable chatter.

HIGH-SPEED STEEL TOOLS

Tests on high-speed steel tools have yielded the following results:

Cutting speed: 60 f.p.m.
Feed: 0·0033 in. per rev.

Rake angle	*Tool life (min.)*
15 deg.	36·2
30 deg.	12·8 30·0
35 deg.	51·4
40 deg.	90·3

These figures show that increasing the rake angle beyond 30 deg. leads to a rising trend in tool life. If the rake angles are considerably increased to 35 deg. or 40 deg., much higher cutting speeds are possible, provided that the feed is relatively fine (0·002 to 0·003 in. per tooth) and that the cutting edges are adequately cooled by either a copious supply of soluble oil or by "mist" cooling. Straight cutting oils are ineffective under these conditions. Using an 18 per cent. tungsten 10 per cent. cobalt steel (which proved much the most suitable) and the high rake angles, a cutting speed of 60 f.p.m. has been found to be practicable.

The above tests were conducted on the Swift lathe shown in the accompanying illustration; it has a speed range continuously variable from 17 to 2,000 r.p.m., and is powered by a 75 h.p. motor. They are now being extended to the use of high-rake high-speed steel fly-cutters on a milling machine.

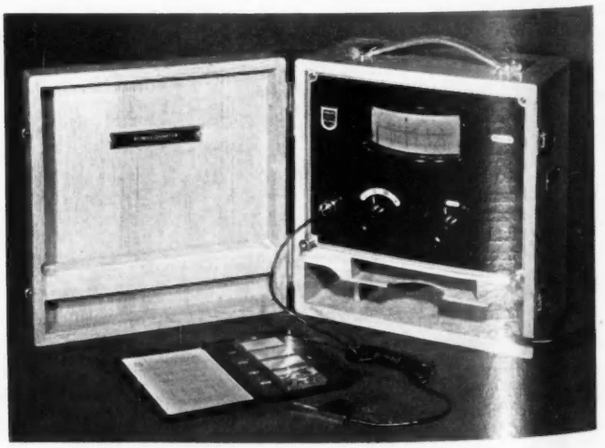
With this high-rake type of tool, cratering does not occur, but failure ultimately results from the formation of narrow grooves across the cutting edge. This observation would suggest that when very high rakes are used tool life will be very much dependent on the presence of abrasive non-metallic inclusions in the work-piece. Attention should also be paid to the structure of the high-speed steel to ensure no loss of strength due to carbide segregation.

CHECKING SURFACE FINISH

Measuring Roughness with a Portable Instrument

To increase the accuracy of their instrument for checking the roughness of machined surfaces, Philips Electrical Limited, Century House, Shaftesbury-avenue, London, W.C.2, have introduced a new set of calibration standards. The four blocks making up the set have been precision machined and individually calibrated by "Talysurf" measurement. They give calibration points of 125, 32, 8 and 2 micro-inches. The instrument, pick-up and standards are shown in the illustration below.

The roughness tester is mains operated, and consists of a moving-coil meter with a measuring pick-up on a flexible lead. The pick-up is 2 in. long and can be inserted in a hole $\frac{3}{8}$ in. diameter. A sapphire stylus, operating in conjunction with a barium-titanate element, follows the contours of the surface when the pick-up is drawn over it; the resulting signal is amplified and indicated on the meter. In operation, the pick-up is first drawn over the comparison standard, and the meter calibration adjusted. Then it is drawn over the surface to be measured, and a direct reading can be obtained. The maximum error is ± 10 per cent., and this can be considerably reduced by a practiced operator. There are four ranges on the instrument, covering roughnesses of centre line averages from 1 to 250 micro-inches; one standard corresponds to the mid-point of each range. The instrument, which weighs 13 lb., can be used on any mains supply between 110 and 245 volts, and 40 to 100 cycles.



Calibrated from the standards supplied, this instrument can measure the roughness of any surface between 1 and 250 micro-inches, simply by drawing the pick-up over it.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

GLASGOW
"Brush Gear," by A. Mair. Glasgow Branch. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Jan. 25, 8 p.m.

British Institution of Radio Engineers

LONDON
Symposium on "Electronic Methods of Pictorial Reproduction":—"Facsimile Communication," by H. F. Woodman and P. H. Taylor; "Fascimile Transmission of Weather Charts," by J. A. B. Davidson; "Tone Reproduction with Electronic Stencils," by Dr. R. Lant; and "Electronic Engraving," by G. S. Allen. London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Jan 25, 6.30 p.m.*
CARDIFF
"Magnetic Amplifiers," by Dr. O. I. Butler. South Wales Section. University College of South Wales and Monmouthshire, Cardiff. Wed., Jan. 25, 6.30 p.m.

British Interplanetary Society

BRISTOL
"Factors Governing the Design of Interorbital Vehicles," by G. L. Garthwaite. Western Branch. Grand Hotel, Bristol. Sat., Jan. 28, 7.30 p.m.

Building Centre

LONDON
Film illustrating cables and tubes in concrete. Wed., Jan. 25, 12.45 p.m.

Chemical Engineering Group

LONDON
"Control of Corrosion in the Heavy Chemical Industry," by D. R. Himsworth and W. D. Clark. King's College, Strand, W.C.2. Wed., Jan. 25, 6.30 p.m.

Electrical Association for Women

LONDON
"Electricity in the Low Countries: The Women in the Industry," by Miss M. S. Mitchell. Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Tues., Jan. 31, 6 p.m.

Engineer Buyers and Representatives Association

LONDON
Discussion on "Finance." Gargoyle Club, 69 Dean-street, W.1. Fri., Jan. 27, 7 p.m.

Illuminating Engineering Society

BATH
"Plastics in the Lighting Industry," by W. E. Harper. Bath and Bristol Centre. Offices of the South Western Electricity Board, Old Bridge-street, Bath. Fri., Jan. 27, 7 p.m.
BIRMINGHAM
Members' contributions on "My Most Interesting Lighting Problem." Birmingham Centre. Regent House, St. Phillip's-place, Colmore-row, Birmingham. Fri., Jan. 27, 6 p.m.
LEEDS
"Interior Lighting and Architects' Thoughts," by F. Chippendale. Leed Centre. Lighting Service Bureau, 24 Aire-street, Leeds 1. Mon., Jan. 23, 6.15 p.m.

Incorporated Plant Engineers

BIRMINGHAM
Discussion on "Industrial Hydraulics." Birmingham Branch. Imperial Hotel, Birmingham. Fri., Jan. 27, 7.30 p.m.
CARDIFF
"Vehicle Maintenance," by R. M. Pringle. South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Jan. 24, 7.15 p.m.
SHEFFILED
"Work Study," by F. R. Curry. Sheffield Branch. Grand Hotel, Sheffield. Thurs., Jan. 26, 7.30 p.m.

Institute of British Foundrymen

BIRMINGHAM
"Metallurgy of Cast Iron," by H. Morrogh. Birmingham Branch. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., Jan. 25, 7.15 p.m.
COVENTRY
"Developments in Mould and Core-Making Processes," by A. Tipper. Coventry Section. Coventry Technical College, Coventry. Tues., Jan 24, 7.30 p.m.
FALKIRK
"Further Thoughts on Cupola Practice," by W. Y. Buchanan. Falkirk Section. Temperance Café, Lint Riggs, Falkirk. Fri., Jan. 27, 7.30 p.m.
WELLINGBOROUGH
"Master Pattern Making Aids Production," by H. Wilson. Northampton Section. Hind Hotel, Wellingborough. Thurs., Jan. 26, 7.30 p.m.

Institute of Fuel

BIRMINGHAM
"The Occurrence, Extraction and Properties of Germanium," by A. R. Powell. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Thurs., Jan. 26, 6 p.m.
LIVERPOOL
Film Display. Merseyside Sub-Section. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Thurs., Jan 26, 7 p.m.
NOTTINGHAM
"Recent Developments in Fuel Technology," by Prof. A. L. Roberts. East Midland Section. Gas Board's Showrooms, Nottingham. Thurs., Jan 26, 6.15 p.m.

Institute of Marine Engineers

LONDON
"Experiences in Ten Vessels: Seventy-Five Voyages with Harland and Wolff Opposed-Piston Engines Burning Boiler Oil," by A. G. Arnold. Tues., Jan. 24, 5.30 p.m.*
CARDIFF
Annual General Meeting. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Mon., Jan. 23, 6 p.m.
NEWCASTLE-UPON-TYNE
"Gas Turbines," by J. R. Bolter. North East Coast Section. Stephenson Building, Claremont-road, Newcastle-upon-Tyne. Thurs., Jan. 26, 6.15 p.m.*

Institute of Petroleum

EDINBURGH
Annual General Meeting. Scottish Branch. North British Hotel, Princes-street, Edinburgh. Thurs., Jan. 26, 7 p.m.

Institute of Refrigeration

LONDON
"The Testing of a Steam-Operated Refrigerator Van," by Dr. J. Andrews. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., Jan. 26, 5.30 p.m.

Institute of Road Transport Engineers

DURHAM
"Lubricants and Greases for Road-Transport Vehicles," by Dr. E. M. Dodds. North Eastern Centre. Three Tuns Hotel, Durham City. Tues, Jan. 24, 7 p.m.
EDINBURGH
"Lubricants and Greases for Road-Transport Vehicles," by Dr. E. M. Dodds. Scottish Centre. North British Hotel, Princes-street, Edinburgh. Mon., Jan. 23, 7.30 p.m.

Institution of Chemical Engineers

LONDON
"Control of Corrosion in the Heavy Chemical Industry," by D. R. Himsworth and W. D. Clark. King's College, Strand, W.C.2. Wed., Jan. 25, 6.30 p.m.

Institution of Civil Engineers

LONDON
"Oxton By-Pass Extension," by R. A. Kidd. Road Engineering Division. Tues., Jan. 24, 5.30 p.m.*
"Construction of a 60 in. diameter Outfall Sewer for Morecambe and Heysham Corporation," by J. K. Brooks and J. S. D. Brown. Works Construction Division. Thurs., Jan. 26, 5.30 p.m.*
BIRMINGHAM
"Space Flight," by R. B. Beard. Midlands Graduates' and Students' Section. Civic Centre, Birmingham. Wed., Jan. 25, 6 p.m.*

Institution of Electrical Engineers

LONDON
"Particle Accelerators," by E. R. Wiblin. Radio and Measurement Sections Joint Meeting. Mon., Jan. 23, 5.30 p.m.* Discussion on "Co-ordination of Overload Capacity," to be opened by H. G. Bell. Supply Section. Wed., Jan. 25, 5.30 p.m.*
LIVERPOOL
"Electrical Energy from the Wind," by E. W. Golding. Mersey and North Wales Centre. Liverpool Royal Institution, Colquitt-street, Liverpool. Mon., Jan. 23, 6.30 p.m.
NEWCASTLE-UPON-TYNE
"Highland Water Power: The Developments of the North of Scotland Hydro-Electric Board," by the late T. Lawrie, read by C. L. Allen. North Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Jan. 23, 6.15 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Recent Developments in Lubricants for Use in Marine Equipment," by V. W. David and L. J. Richards. Tues., Jan. 24, 7.30 p.m.

Institution of Heating and Ventilating Engineers

NEWCASTLE-UPON-TYNE
"Gravity Pipe Sizing Extraordinary," by T. H. F. Holman. North East Coast Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Tues., Jan. 31, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Problems in the Erection of Power Stations." Steam Group. Wed., Jan. 25, 6.45 p.m.* Three papers on sandwich courses, by D. A. Wrangham, R. McCrae and W. K. Rooney, respectively. Meeting in conjunction with the Education Group. Fri., Jan. 27, 5.30 p.m.* Annual Lecture on "Naval Engineering," by Vice-Admiral Sir Frank Mason. London Graduates' Section. Sat., Jan. 28, 3 p.m.
BIRMINGHAM
Open Meeting. Birmingham A. D. Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Tues., Jan. 24, 6.30 p.m.
BRISTOL
"Commercial Vehicle Structures," by P. Brunton. Western A.D. Centre. Royal Hotel, Bristol. Thurs., Jan. 26, 6.45 p.m.
CARDIFF
"Fatigue of Metals and Materials," by Professor H. C. H. Gurney. Annual General Meeting. South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Jan. 24, 6 p.m.
LIVERPOOL
"The Application of Plastics to the Manufacture of Automobile Bodies and Components," by D. S. Mahon. North Western A.D. Centre. 24 Hatton-gardens, Liverpool, 3. Tues., Jan. 24, 7.15 p.m.
SLOUGH
"Engineering Aspects of a Public Water Supply," by T. Irvine Hudson. Eastern and Southern Branches Joint Meeting. Good Companions Hotel, Slough. Tues., Jan. 24, 7.30 p.m.

Institution of Production Engineers

CARDIFF
"Electro Spark Machining," by A. D. P. Tallents. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Jan. 27, 7 p.m.
DARLINGTON
"Mechanical Handling of Materials," by F. T. Dean. Technical College, Darlington. Tues., Jan. 24, 7 p.m.
LINCOLN
"Rubber Reduces Maintenance and Improves Working Conditions," by M. Horovitz. Lincoln Section. Ruston Club, Unity-square, Lincoln. Thurs., Jan. 26, 7.30 p.m.
MANCHESTER
"Production of Agricultural Implements," by D. I. MacDonell. Manchester Section. College of Technology, Sackville-street, Manchester. Mon., Jan. 23, 7.15 p.m.
WORCESTER
"Transfer Machines," by H. W. Holbeche. Worcester Section. Cadena Café, Worcester. Wed., Jan. 25, 7.30 p.m.

Institution of Structural Engineers

LONDON
"Steelwork in Transit Shed 102 Southampton Docks," by F. M. Bowen and B. E. S. Ranger. Thurs., Jan. 26, 6.30 p.m.
BIRMINGHAM
"Design of Crane Gantries and the Action of Cranes on Tracks," by P. M. Worthington. Midland Counties Branch. James Watt Memorial Institute, Great Charles-street, Birmingham. Fri., Jan. 27, 6 p.m.

Junior Institution of Engineers

LONDON
"Principles of Fuel Technology," by J. T. Veryard. Fri., Jan. 27, 7 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Nuclear Reactors for the Generation of Power," by C. E. Iliffe. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Fri., Jan. 27, 6.15 p.m.

Reinforced Concrete Association

EDINBURGH
"Weight-Batching and Control of Concrete," by P. Russell. Scottish Branch. North British Hotel, Princes-street, Edinburgh. Tues., Jan. 24, 6.30 p.m.*

Royal Aeronautical Society

LONDON
"Low Consumption Jet Engines," by A. A. Lombard. Tues., Jan. 24, 7 p.m.

Royal Institution

LONDON
"World Needs and World Resources," by Sir Harold Hartley. Fri., Jan. 27, 9 p.m.

Royal Statistical Society

CARDIFF
"Coding Material for Punched Card Analysis," by Dr. J. A. H. Waterhouse. South Wales Industrial Applications Group. University College, Cardiff. Fri., Jan. 27, 7 p.m.

Royal United Service Institution

LONDON
"The British Transport System," by Sir Brian Robertson. Wed., Feb. 1, 3 p.m.

Sheffield Metallurgical Association

SHEFFIELD
Annual General Meeting and Presidential Address. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield, 3. Tues., Jan. 24, 7 p.m.

Société des Ingénieurs Civils de France (British Section)

LONDON
Presidential Address: "Reflections on Civil Engineering Practice," by L. Turner. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Jan. 25, 5.30 p.m.*

Society of Instrument Technology

CHELTENHAM
Discussion on "Closed-Circuit Television." Cheltenham Section. Rotunda, The Promenade, Cheltenham. Mon., Jan. 23, 7.30 p.m.
CHESTER
"Pneutronics," by J. E. Fielden. Chester Section. 5 King's Buildings, King-street, Chester. Wed., Jan. 25, 7 p.m.

Women's Engineering Society

MANCHESTER
"Industrial Heating," by J. Eddyshaw. Central Library, Manchester. Thurs., Jan. 26, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough-gardens, London, S.W.1.
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Engineering Group, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Electrical Association for Women, 25 Foubert's-place, London, W.1. (GERrard 5212.)
Engineer Buyers and Representatives Association, 47 Victoria-street, London, S.W.1. (ABBey 3583.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Refrigeration, Dalmeny House, Monument-street, London, E.C.3. (MINcing Lane 6851.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne, 1. (Newcastle 20289.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Royal United Service Institution, Whitehall, London, S.W.1. (WHItehall 5854.)
Sheffield Metallurgical Association, 15 Crescent-road, Sheffield 7. (Sheffield 53674.)
Société des Ingénieurs Civils de France (British Section), 82 Victoria-street, London, S.W.1. (VICtoria 6838.)
Society of Instrument Technology, 184 Sherwood Park-road, Mitcham, Surrey. (POLlards 3620.)
Women's Engineering Society, 25 Foubert's-place, London, W.1. (GERrard 5212.)

THE HUMAN ELEMENT

A stop-watch on the shop floor—Opposition to Communism in industry—Shop stewards try to run the motor industry—Not enough men to run the mines—How to preserve the value of pensions—Are farm workers worth more?

★ ★ ★

Time and Motion Study Marches On

The memory of Mr. Bedoe's white-coated men with stop-watches of the early 1930's is still vivid with many of us, as is the memory of the slump of those years. Time and motion study was then widely synonymous with "axing" workers: there were many strikes in protest and a strong dislike of the method sank deep in the trade union mind. A dislike so deep-rooted that whole industrial groups still ban stop-watches from the factories in which they work.

Last week, for the first time, a British trade union gave its backing to the systematic application of time and motion study within its industry. The National Union of Boot and Shoe Operatives, under the very constructive leadership of their president, Mr. James Crawford, have concluded an agreement with the Footwear Manufacturers' Federation in which the principles to govern the introduction and application of the method are laid down. No attempt is made to force the hands of employers or workers, but a clear lead is given "for the benefit of manufacturers who may wish to introduce it." The way is now open for the evaluation of jobs and their classification into the three grades (for adult workers), each with specific rates per standard minute, defined in the agreement. An important provision is for the maintenance of differentials between the various grades of operatives: the skilled man stands to gain far more than the unskilled, but the door to the skilled grades is wide open.

The industry's experience in the past ten years, during which 17 out of the 400 firms in the industry are said to have used the method, is most encouraging. Gains in output range from 25 to 80 per cent., and one firm of 2,000 employees reports an increase of 35 per cent. in output and of 25 per cent. in wages. The agreement is a personal triumph for Mr. Crawford, who is chairman of the British Productivity Council and also of the T.U.C. Production Committee.

★ ★ ★

Common Cause

The fight against Communist penetration of the trade unions is being led by an organisation which, in single-mindedness and drive, gives very little away to the Communist Party. Common Cause—"Freedom, the Common Cause of Mankind"—have since their formation in 1952 displayed the hard-hitting qualities and initiative normally associated with extremist political movements. Yet they are fighting "to maintain in Britain political democracy, the rule of law, and the maximum of individual freedom compatible with the discharge of social and civic duties." All enemies of the freedom of the individual are legitimate quarries, whether of the McCarthy, Hitler or Poujade varieties, and of course the Communists. Their second object is quite explicit: "to expose the Communist Party of Great Britain as a treacherous conspiracy serving a foreign dictatorship."

This is a new phenomenon, quite different in its conception from the liberal tradition in British politics. They seek to become major and effective opponents of Communism by constant exposure of the latter's belief in dictatorship and its foreign roots. To do this, Common Cause have organised country-wide activities. They operate an industrial committee whose members are all trade unionists, hold lecture courses, publish a regular bulletin, leaflets and pamphlets, contribute articles to journals and magazines, offer their lecturers to other organisations and to the Services, maintain an information service, operate a film unit which takes films into factories, organise opposition to Communist rallies and in general fight all along the line to secure their objective.

Two beliefs are quite basic to the *raison d'être* of the organisation. First, Communists are gaining ground among organised labour and will go on doing so at an accelerating rate unless they are opposed. Second, greater political consciousness and activity among the mass of organised labour will swamp Communism. This may well be so, but the lesson of other countries is that Communism thrives on tough opposition and, in our own, that it flounders against indifference—or does it?

★ ★ ★

Vehicle Shop Stewards Retaliate

Austin's imposition of a four-day working week (Human Element, January 13) has led to swift retaliatory action by the shop stewards of the British Motor Corporation factories. At a meeting held in Birmingham last Saturday, they decided to ask the 40,000 trade union members in the Corporation to ban all overtime until full-time working is restored at Longbridge. They also decided to call a meeting of shop stewards representing the Big Six of the motor industry to consider similar action. Should this request be successful it would have the unprecedented effect of making it impossible for any one company to lose ground in the competitive race, since the workers of the other companies would immediately restrict their output to absorb the short-fall in orders.

The B.M.C. shop stewards have also raised wider issues which include asking the management to press the Government to lift the embargo on exporting vehicles to China, to enable a deal for more than £1 million worth of lorries to be concluded. They are also to request the Government to reverse the budget restrictions on hire purchase and to reduce the purchase tax on cars. In this manner they hope to re-open the home market in a way that will ensure full employment for all the workers in the industry. At the same time, presumably in case these measures do not come off, they are pressing for a shorter working week of 40 hours instead of 44 hours at the same pay, and also giving their full support to the 15 per cent. wage increase which is at present being negotiated.

It is difficult not to conclude that the B.M.C. shop stewards are asking for a great deal more than either the Government or their industry can do for them, even if they agree to their requests. At the same time their action is a reminder that when an industry acquires the importance of the motor industry the labour element is a positive force which cannot be ignored. It could take the competitive edge right out of one of our most competitive industries.

★ ★ ★

Manpower and the Mines

Those hardy annuals, manpower wastage and recruitment, were again prominent in the National Coal Board's review of the past year. Sir Hubert Houldsworth quoted figures which showed that the National Coal Board were no nearer to solving their basic problem of recruitment in 1955 than in 1954. Total recruitment was 61,200, a slight improvement, but the reverse was true of industrial areas. The major effort made to reduce wastage was unsuccessful: it increased by 5,800 to 66,800. The net decline of 5,200 in the industry's labour force has raised the number of vacancies to 13,000.

The wastage of manpower is by no means confined to the older workers, but spread evenly over all age groups. Why do men leave the industry, despite the considerable improvements in pay and working conditions effected since the war? The N.U.M.'s diagnosis is not enough pay and an unsatisfactory system of bonus payments. Their president, Mr. Ernest Jones, said that unless their claim is met in full, workers would continue to drift away from coal mining.

This disquieting situation has existed for too long, and should not be allowed to remain a major threat to the country's prosperity. The problem is most certainly complex but surely not without a practical solution. Dr. Fleck's inquiry into the administration of the Board could well be followed this year by an equally thorough inquiry into recruitment and wastage of manpower. But it should be done by the Board, not by an external committee.

★ ★ ★

Pensions and Inflation

Some of the hardest hit members of the community in times of inflation are pensioners. When a man goes on pension his income remains fixed although prices do not. To-day, more and more salary and wage earners are becoming pensionable and while this is a most valuable help towards security in old age, the thought that if a healthy man lives on pension for fifteen to twenty years he may have to face up to a 10 to 15 per cent. increase in prices is a disquieting reflection.

In Sweden discussions have been taking place on how this problem might be tackled. A Royal Commission has suggested that pensioners' incomes should rise in line with average incomes. Under this system, every income earner would commence contributing at 17 and draw a pension at 67. He would get one earlier if incapacitated. Contributions would cease at 64. Premiums would be graded up to a certain income level, employers would pay 50 per cent. and employees about 8 per cent. A points system would be used to relate the employee's income to the average income during his earning years and when he became eligible for pension his points would be added up and for every point he would get 0·75 per cent. annually of the average income in Sweden in the year in question. This pension would be paid from current contributions and in this way rising national production would favour the pensioner.

★ ★ ★

Farm Workers

The attitude of industry and many sections of organised labour towards the farm worker owes its inspiration to-day far too much to the rural conditions of the Eighteenth Century. He is much too readily viewed as the uncouth, unskilled Tommy Atkins of the industrial army—or to bring it nearer home, all right for the Pioneer Corps but hardly fit for the R.E's. But to-day the farm worker has to have a working knowledge of a wide range of subjects and as much nous about machinery as most garage hands.

His wage rates reflect the general attitude to his industrial status. His minimum wage rates are low and he is badly placed for overtime earnings and bonus payments. He may have a tied cottage, but the amenities are not likely to be outstanding. He is thus under constant pressure to leave the countryside for the towns in search of higher earnings. This goes on at a time when an effort is being made to raise agricultural output and to mechanise farming methods. The danger is that if the present trend continues there will not be sufficient labour in due course to man the machines. That machines will replace men there is no danger at all.

It is not surprising therefore that agricultural workers are not satisfied with their recently confirmed wage award and that they are back in the queue of organised workers seeking higher wages at the present time—a queue which altogether is asking for increases amounting to about £400 million a year. So far as farm workers are concerned, the issue is not really one of merely higher wages as such but of industrial up-grading.

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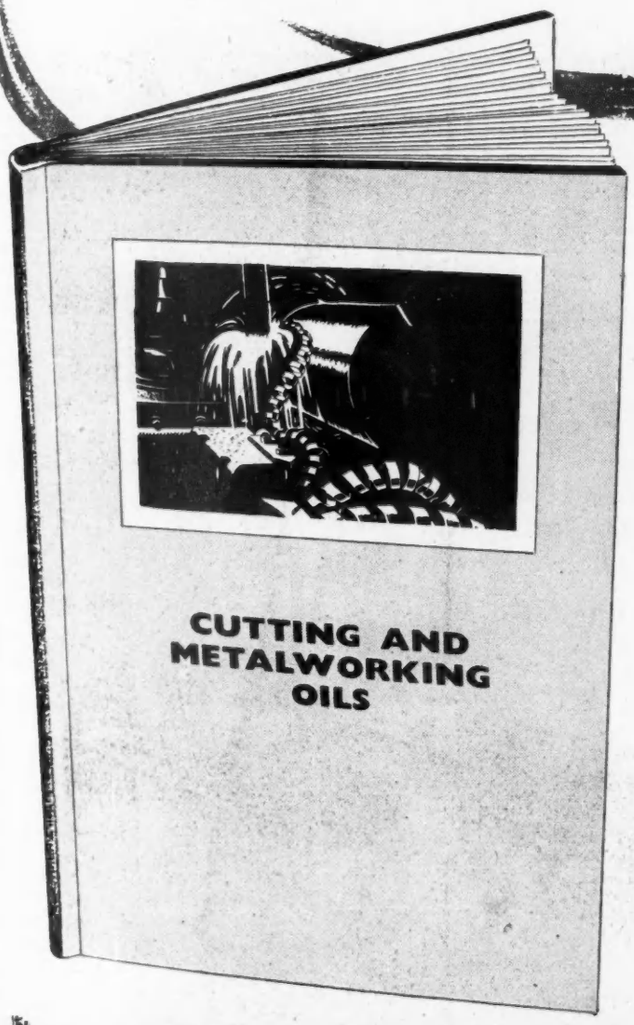

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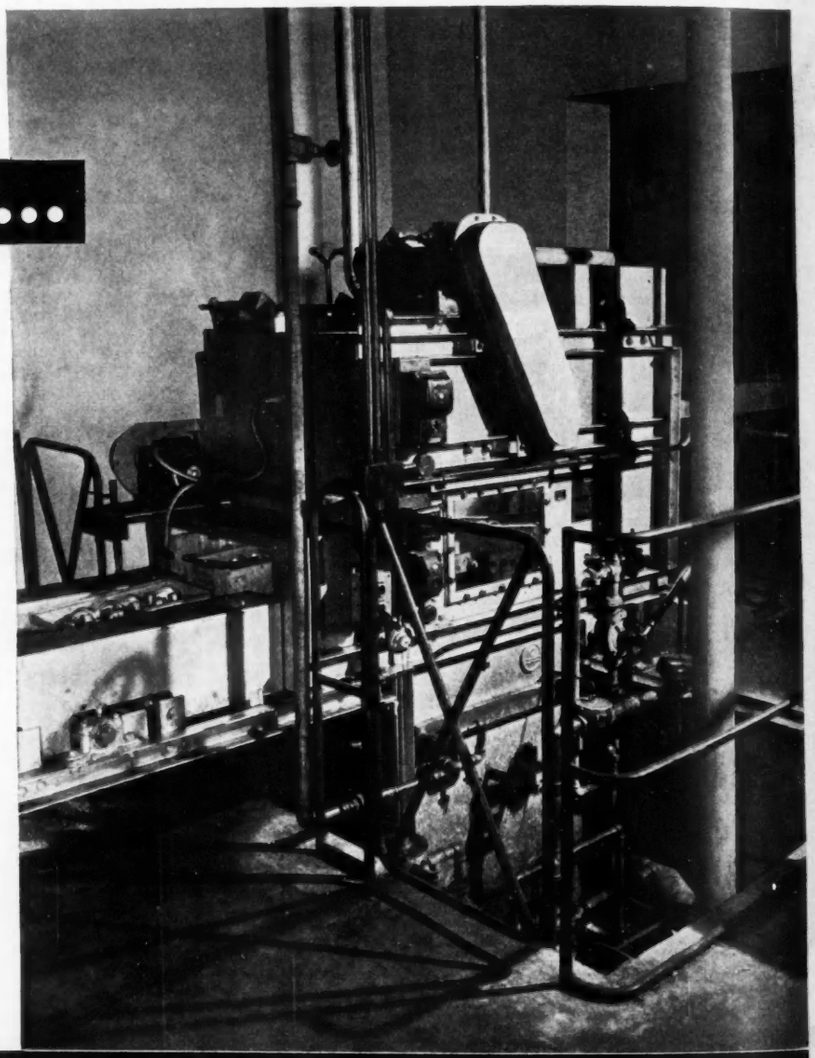

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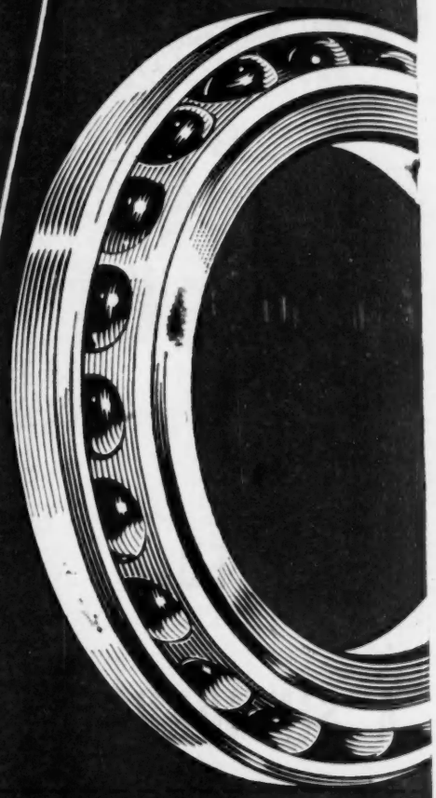

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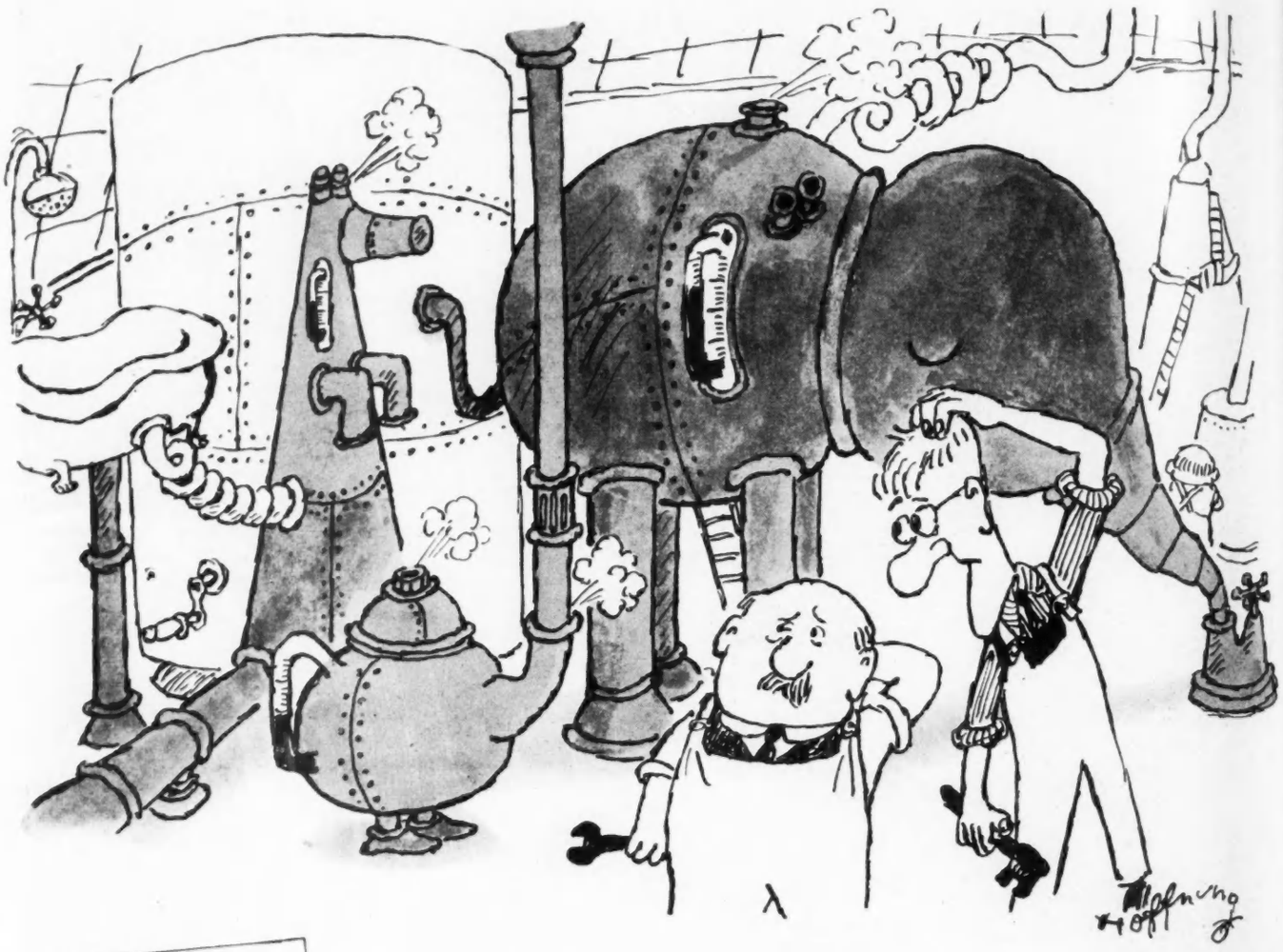

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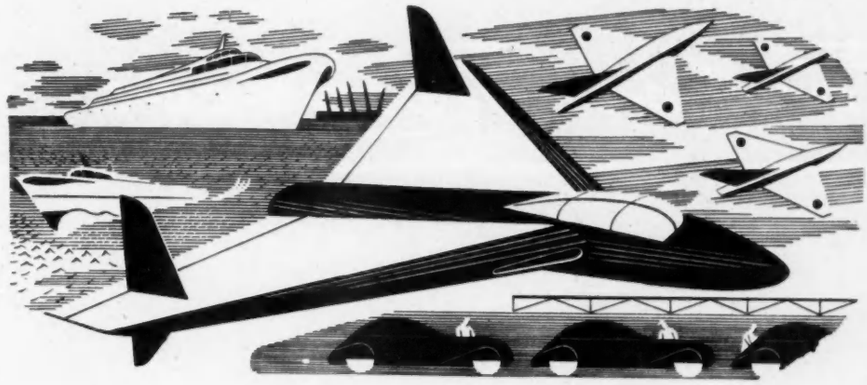

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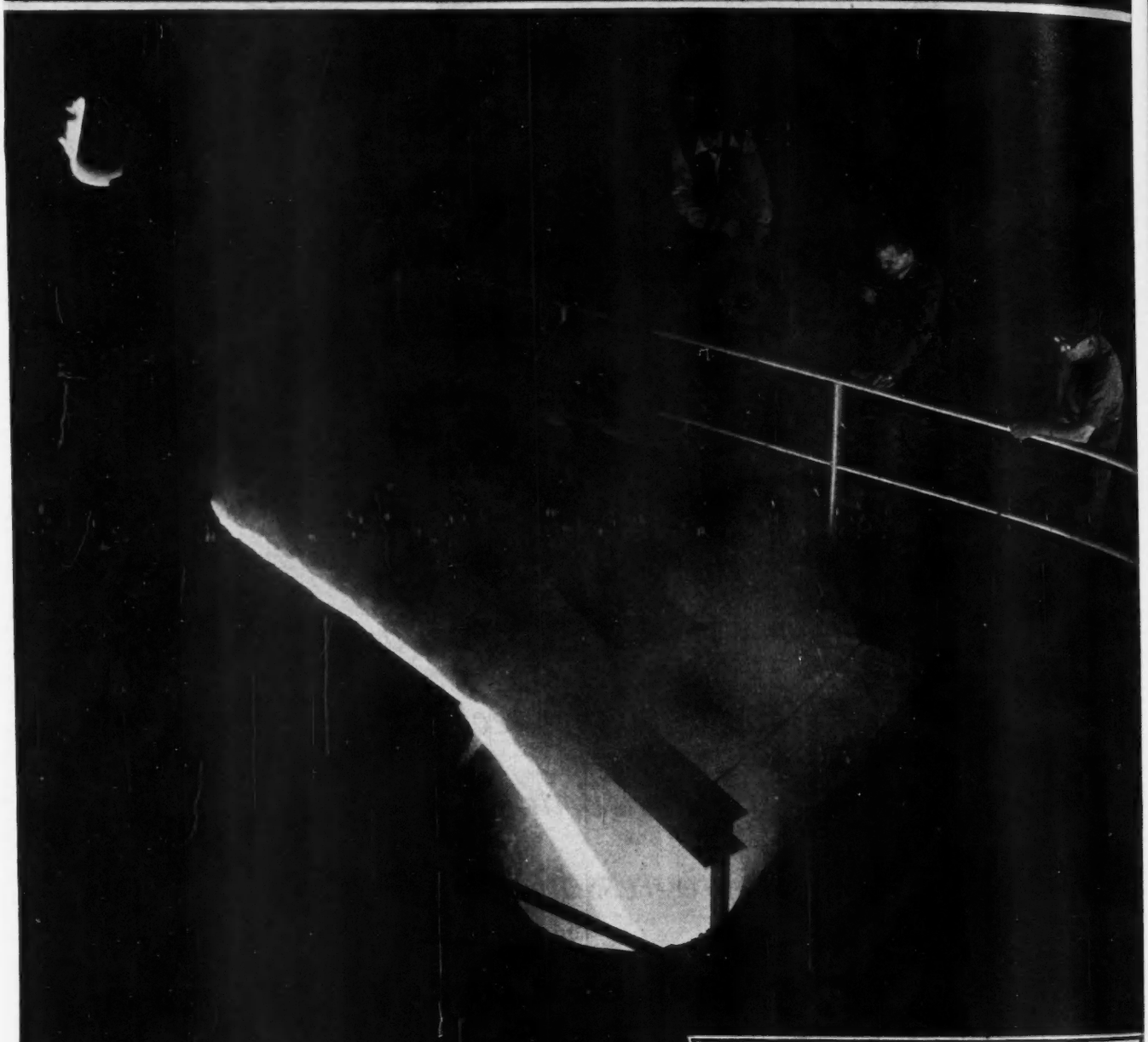

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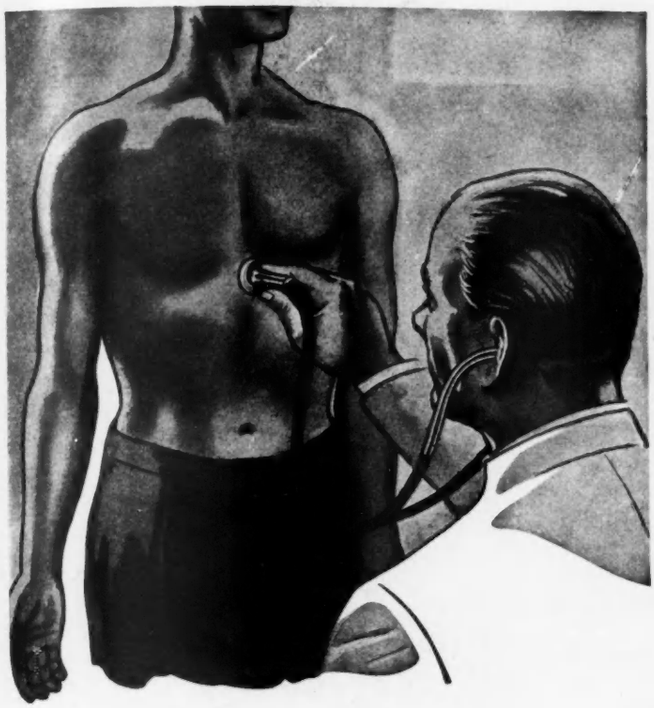

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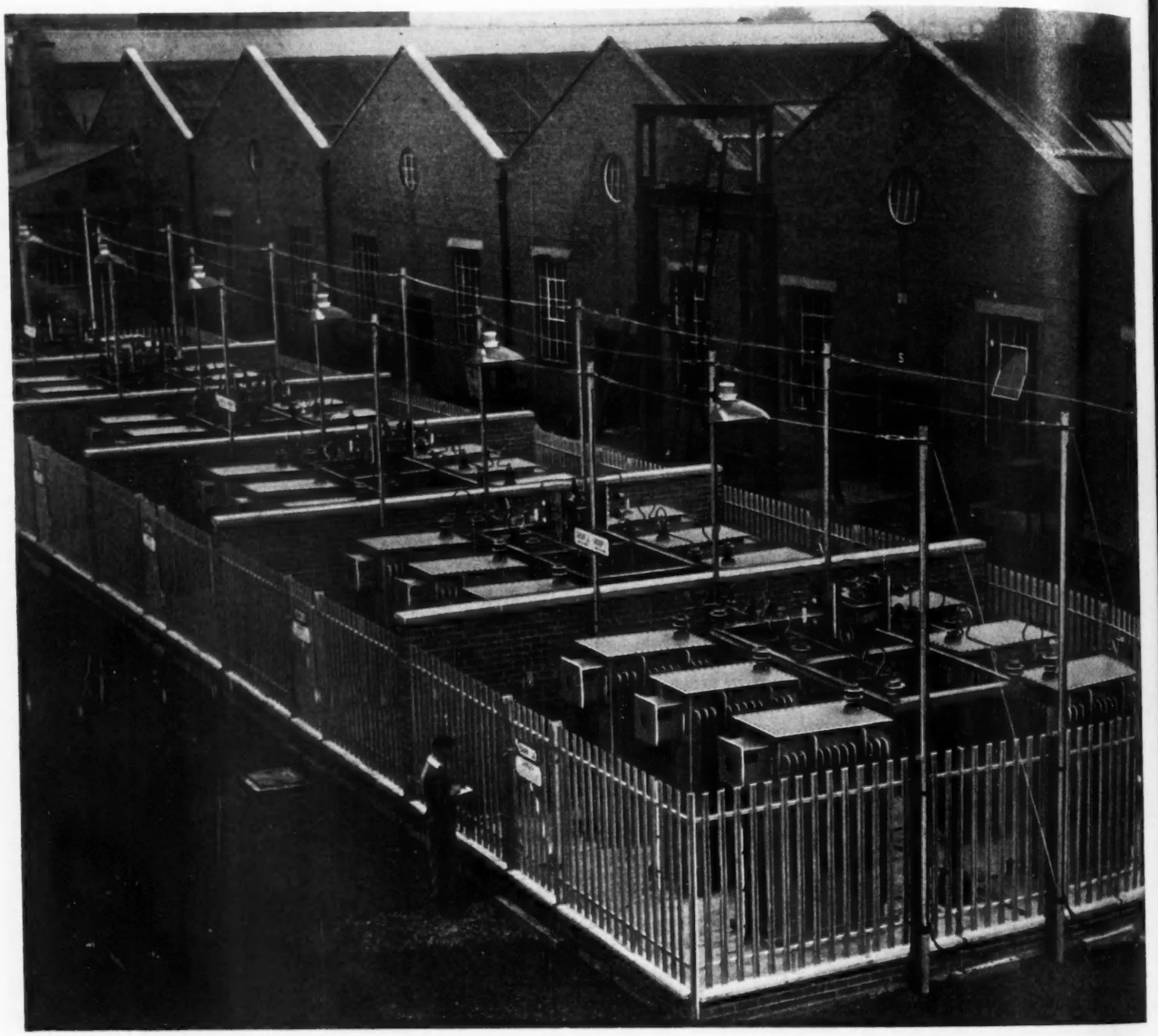

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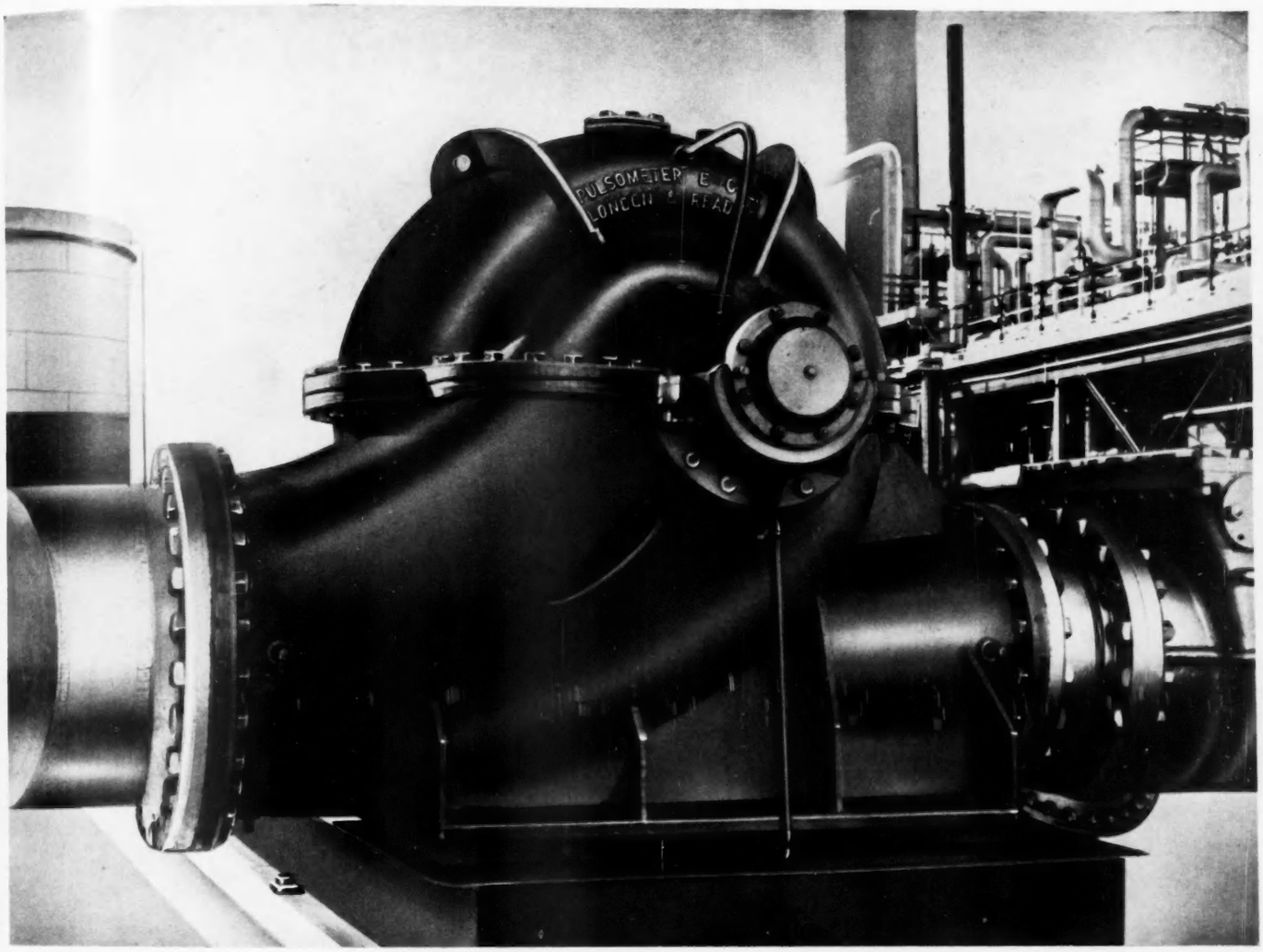
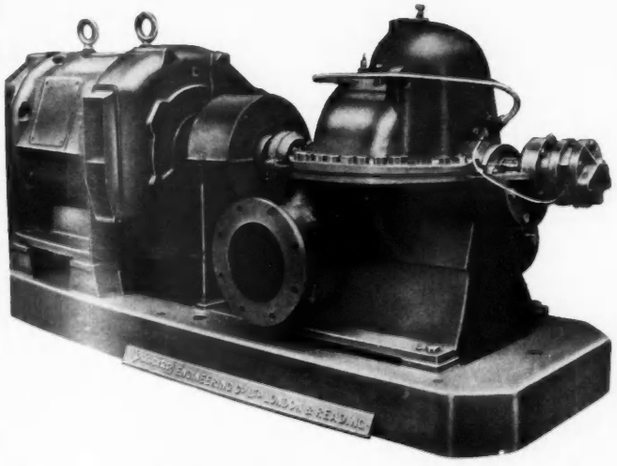


The above shows a 24/30 ins. split-casing pump supplied to an oil refinery.



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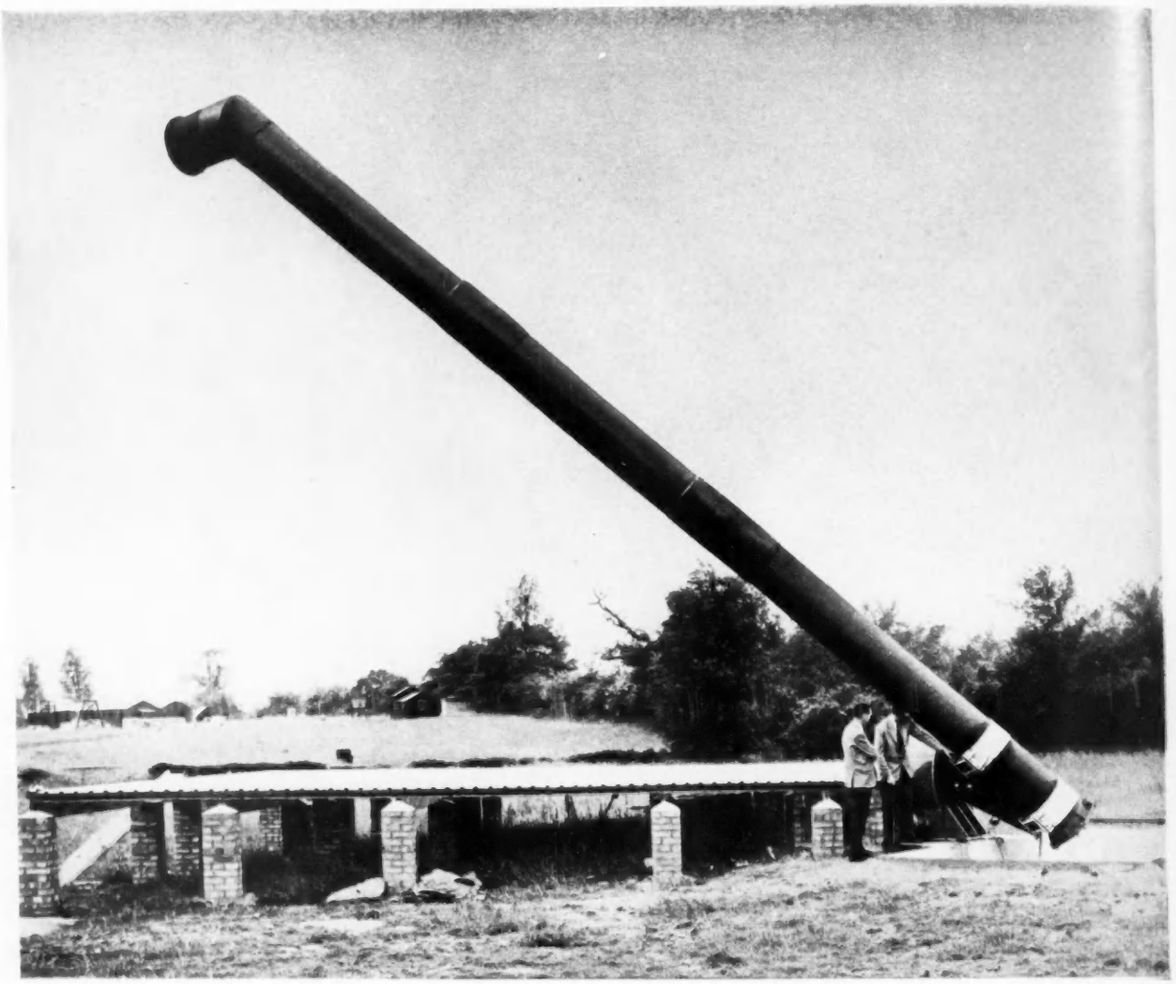

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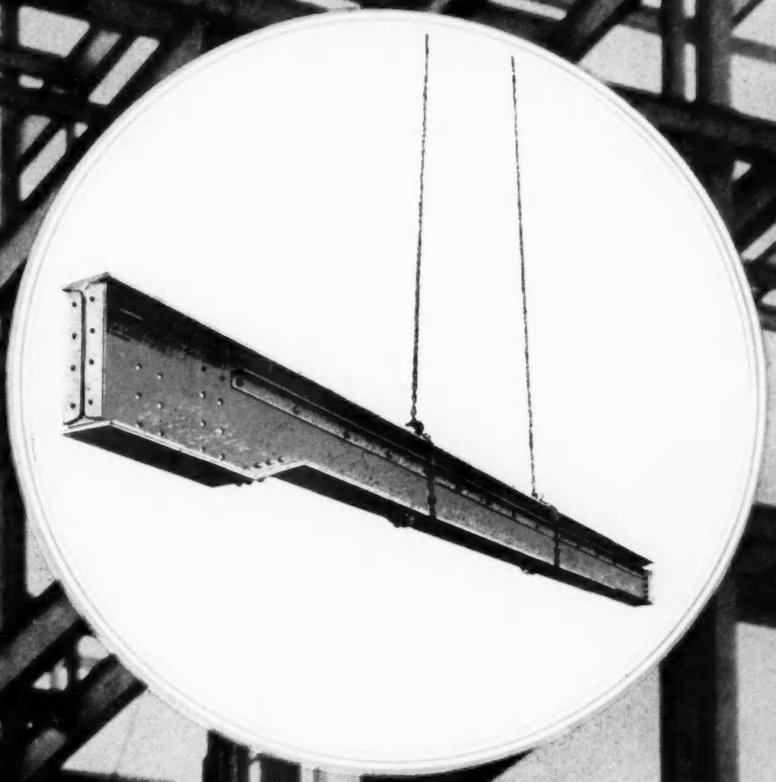

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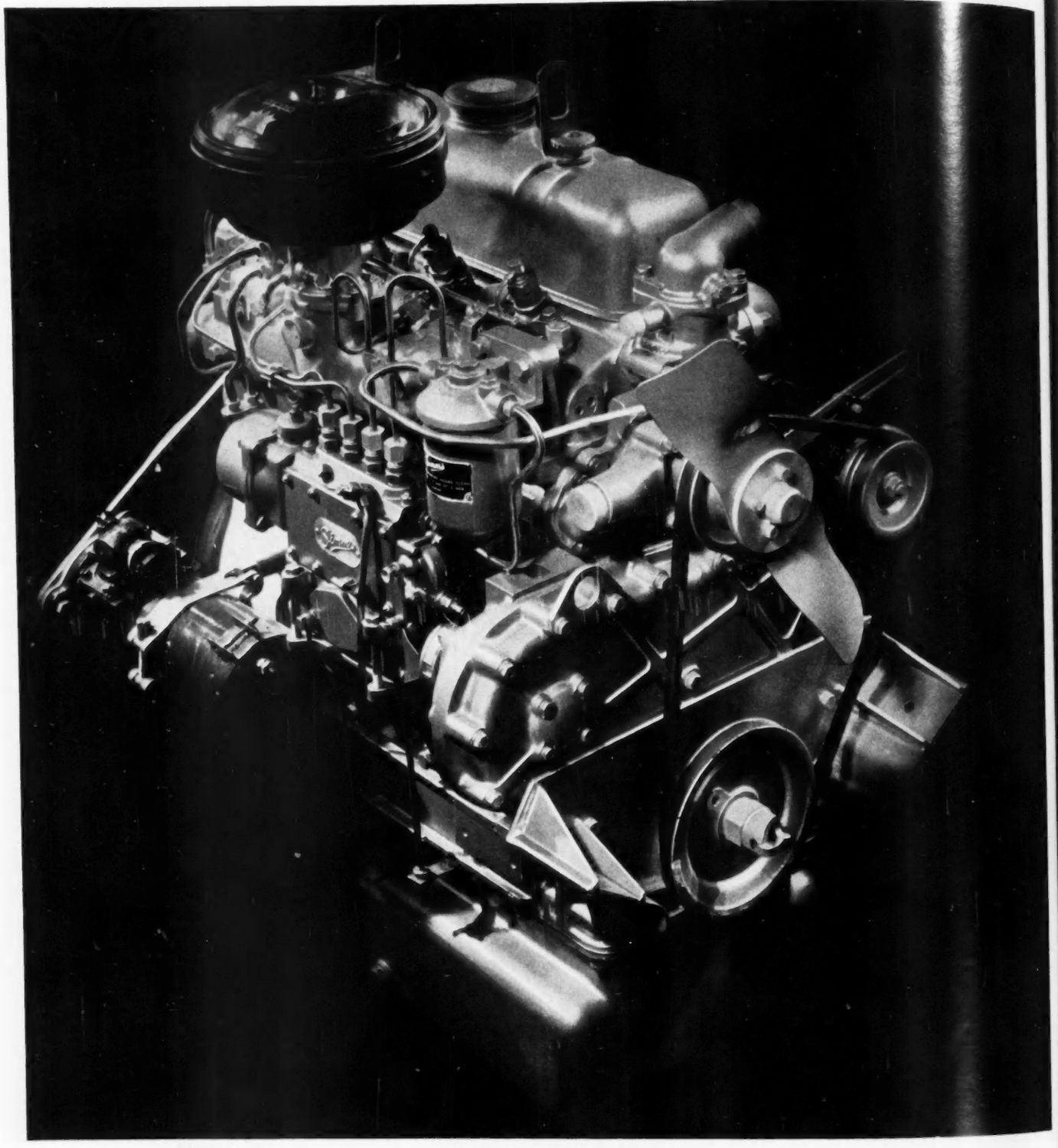

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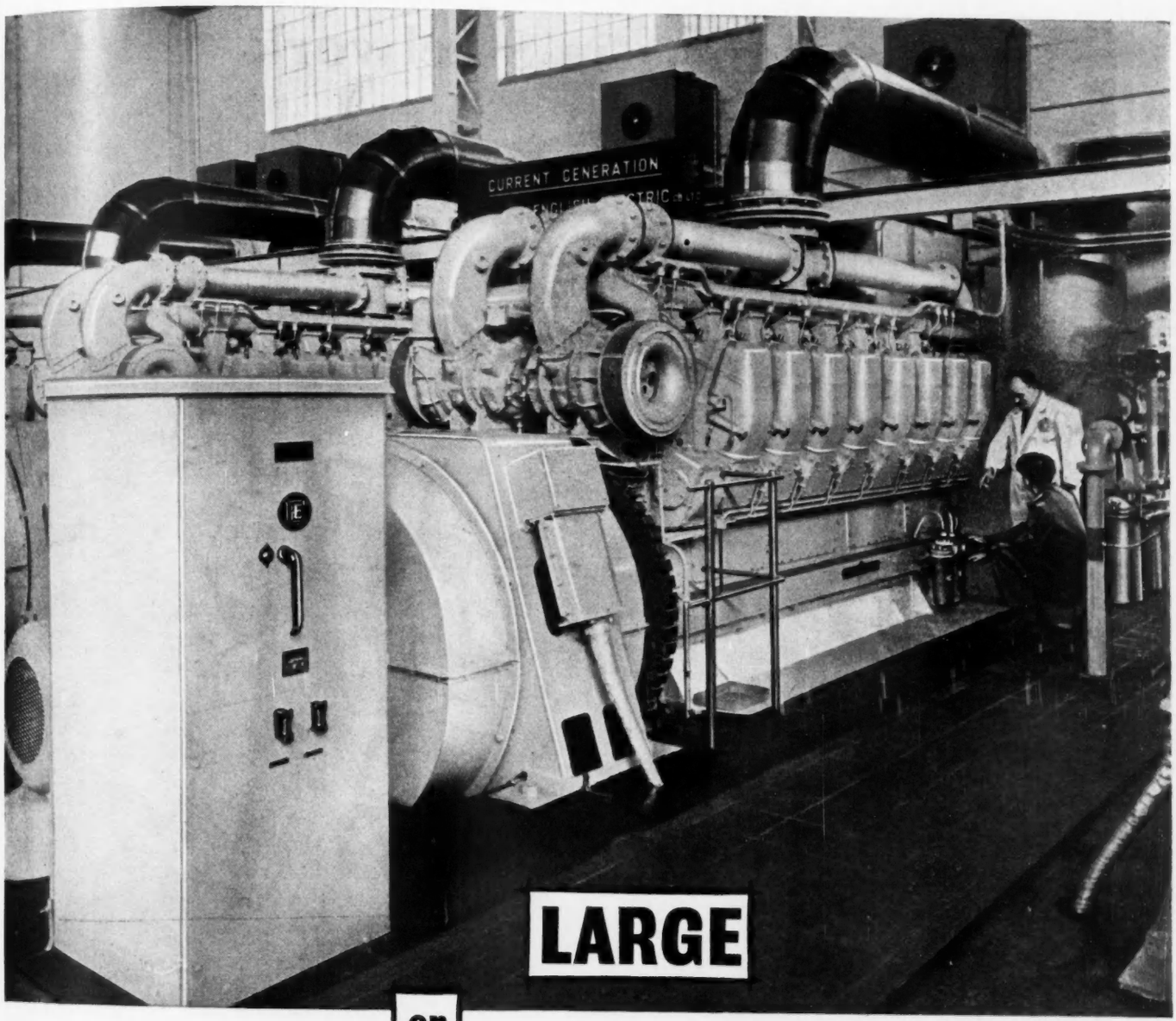

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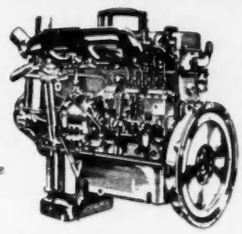

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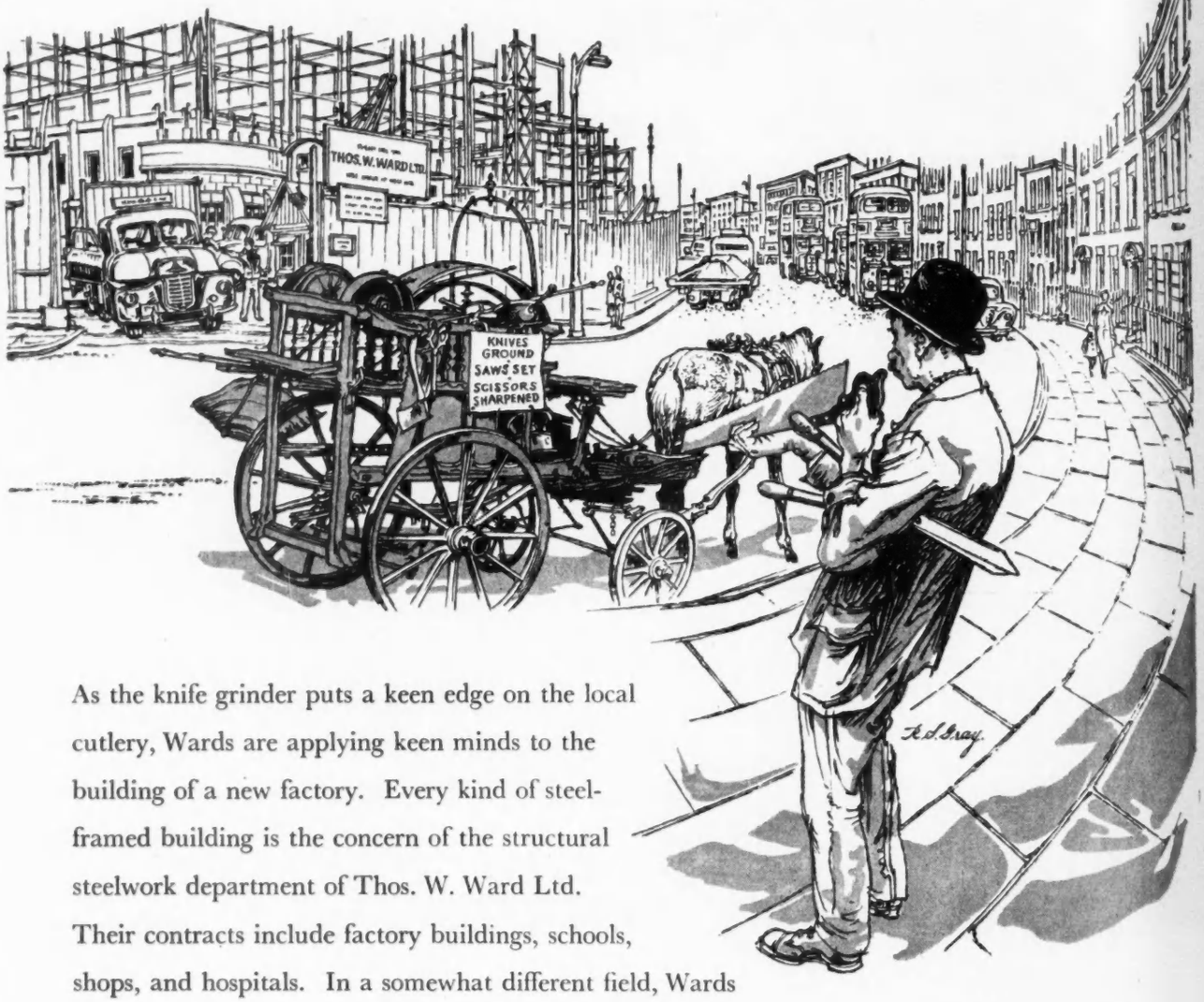

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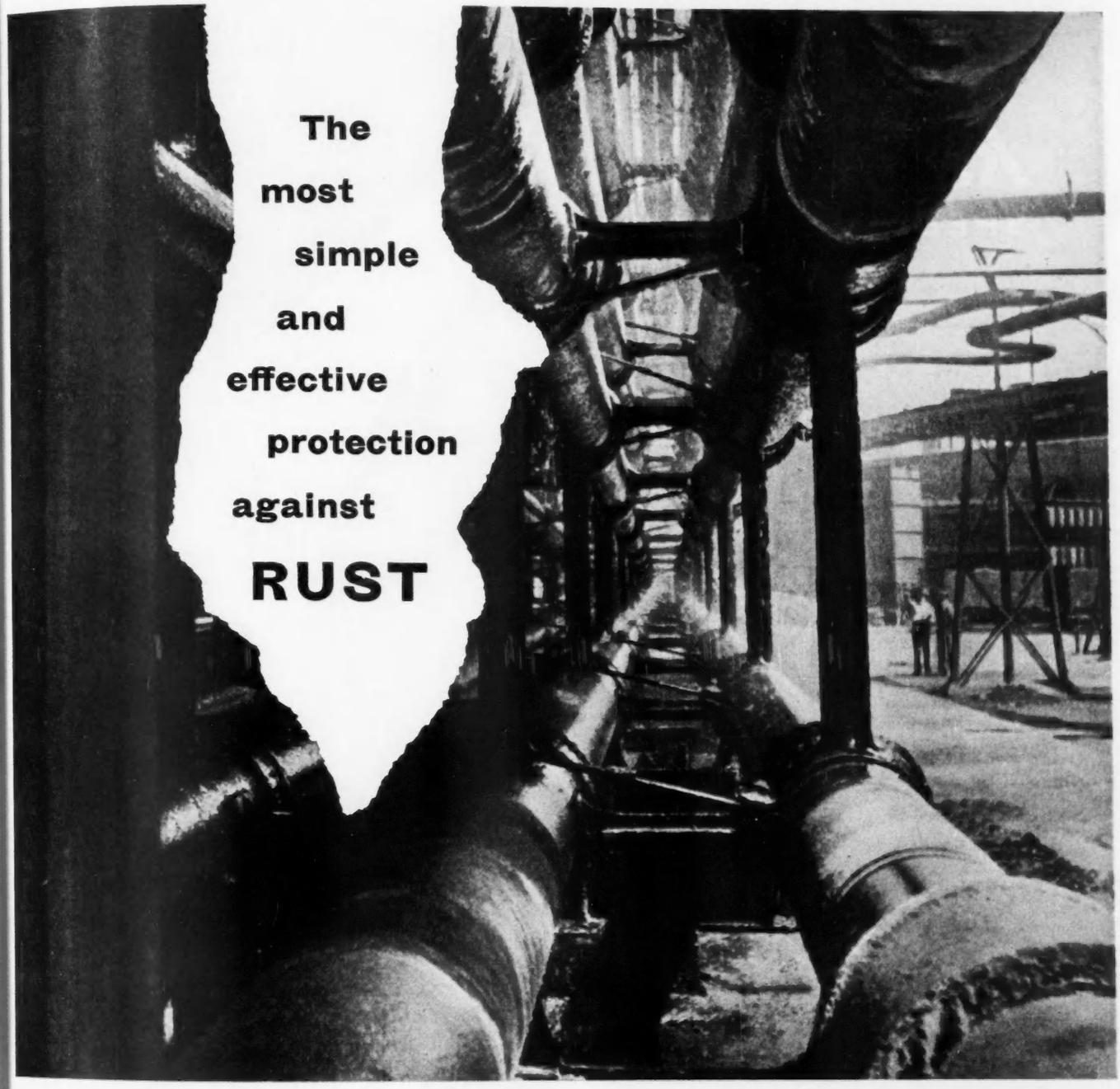

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ALLSPEEDS LIMITED, OAKENSHORE WORKS, CLAYTON-LE-MOORS, ACCRINGTON, LANCS, *Telephone:* ACCRINGTON 3214 (3 lines)
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Detergent engine oil for Plant and Transport engines.

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Extreme pressure gear oil for transmission, final drive and axle lubrication.

DUCKHAM'S No 27

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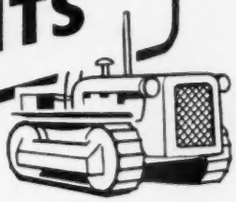
Duckham's

CONTRACTORS PLANT LUBRICANTS



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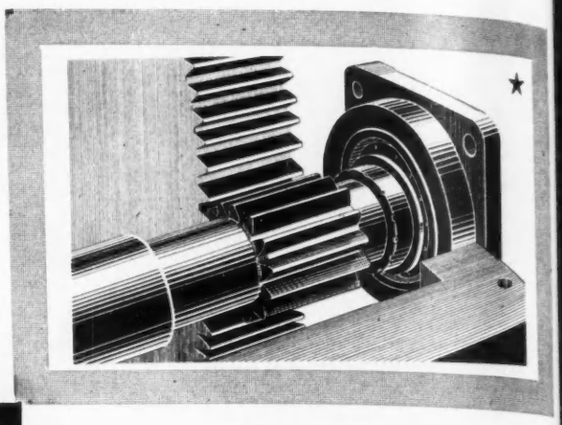
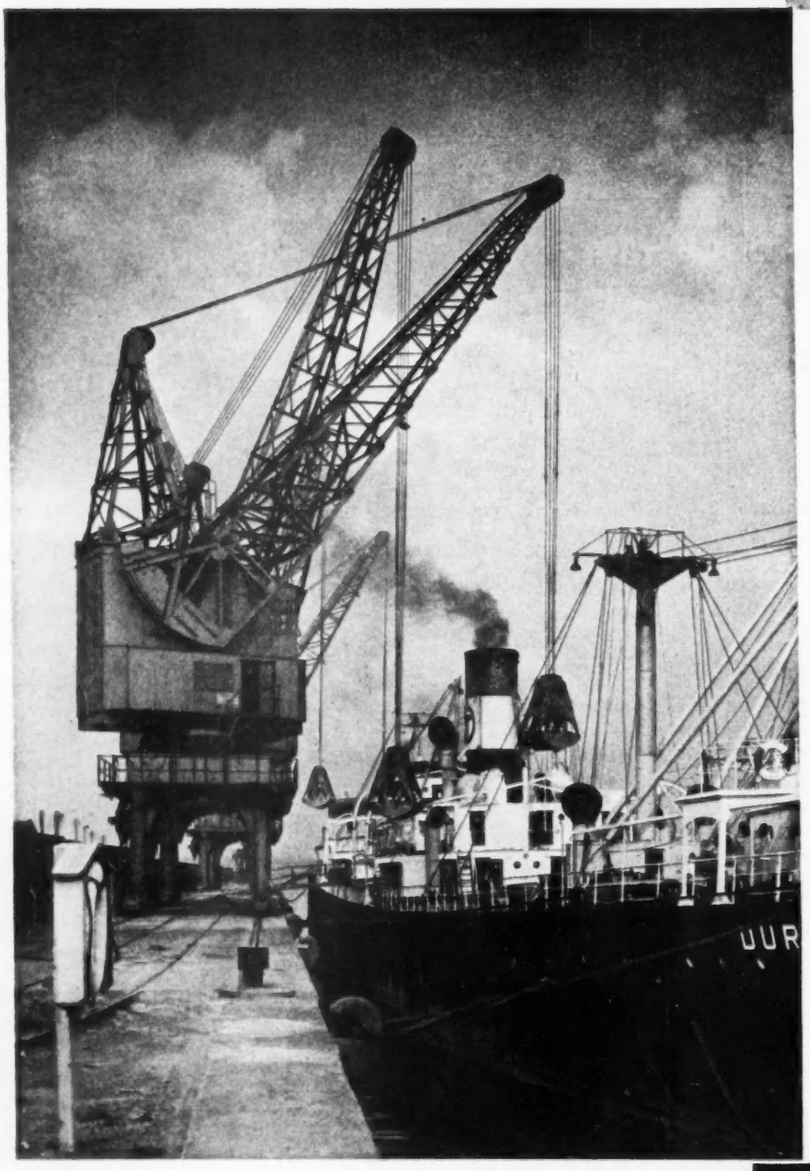
Clyde 7½ tons Level Luffing Cranes at work on the Manchester Ship Canal





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Clyde Crane & Engineering Co.,
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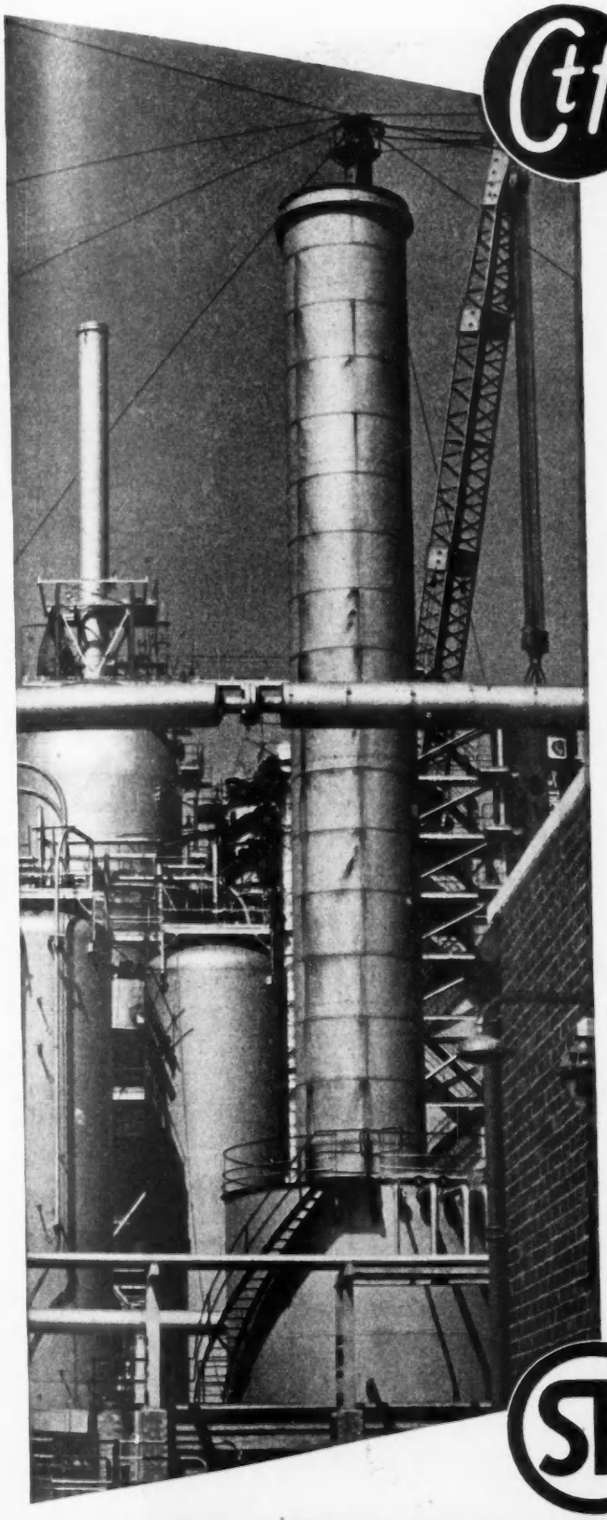

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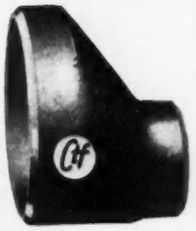

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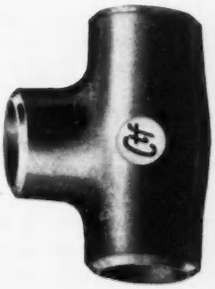

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The MIKRO Airlock is normally equipped with a standard 1/4 h.p. motor and V-belt drive. Adaptable for many applications where it is desirable to unload or discharge material continuously.

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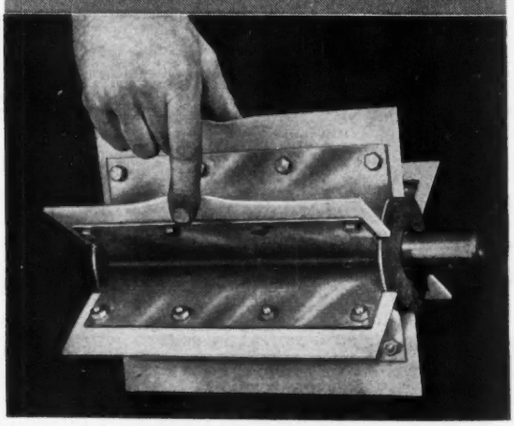

New vanes keep material from binding rotor.

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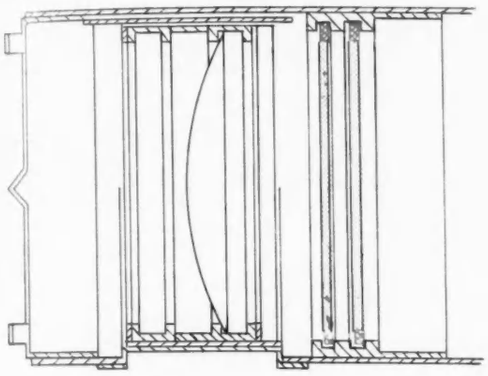

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WELDED FABRICATION

Another example of Butterley welded fabrication — this time in Jamaica, British West Indies — is the specially designed travelling bridge for unloading bauxite ore from scrapers and tractor-towing trailers. The span of the platform is 57 ft. 8 in. 38 tons of steelwork were used in the construction of this bridge

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When it comes to WELDING

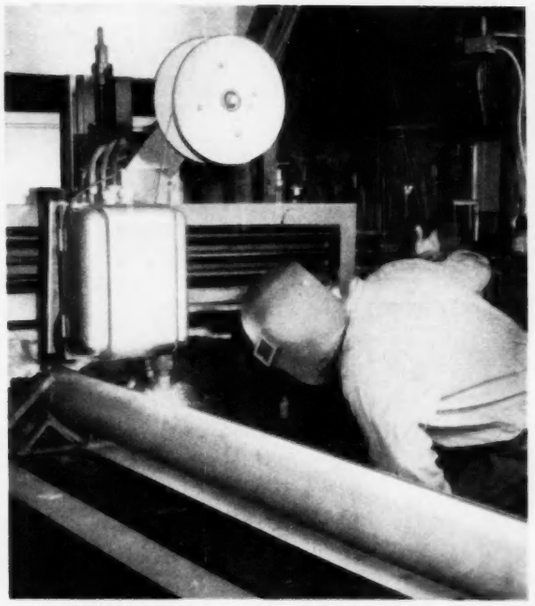
The interests and activities of The Quasi-Arc Company Limited and Fusarc Limited in the well-known processes

Quasi-Arc • *Fusarc* • *Unionmelt* • *Sigma* • *Heliarc* • *Twin-Arc*

were combined on 1st October, 1955 in order to provide a thoroughly comprehensive and effective service to the welding industry.
The headquarters of the new organisation—named Quasi-Arc Limited—are at Bilston, Staffordshire, with works at Bilston and Gateshead.

Great Guns! by *Sigma*

SWM 2 welding of an aluminium tank in the horizontal-vertical position.



SWM 3 machine, beam mounted for welding the longitudinal seams of pipes. (The SWM 3 may also be track mounted).

Manual . . .

Argon-shielded welding with the famous lightweight Sigma 'gun' is really fast. Welds come up clean, so finishing time is cut right down. There's no flux, no spatter, and no corrosion problem. The equipment is sturdy—easy to control, electrically governed and completely reliable. Ease of handling is a special feature resulting from the flexible 50-amp. cable, combined with water cooling of the gun.

. . . and Automatic

Fully-automatic Sigma welds mild steel, stainless steels and aluminium and its alloys in any thickness down to 16 gauge. By increasing welding speeds and producing high quality welds, automatic Sigma cuts production delays and gives a striking increase in output.

Come to QUASI-ARC

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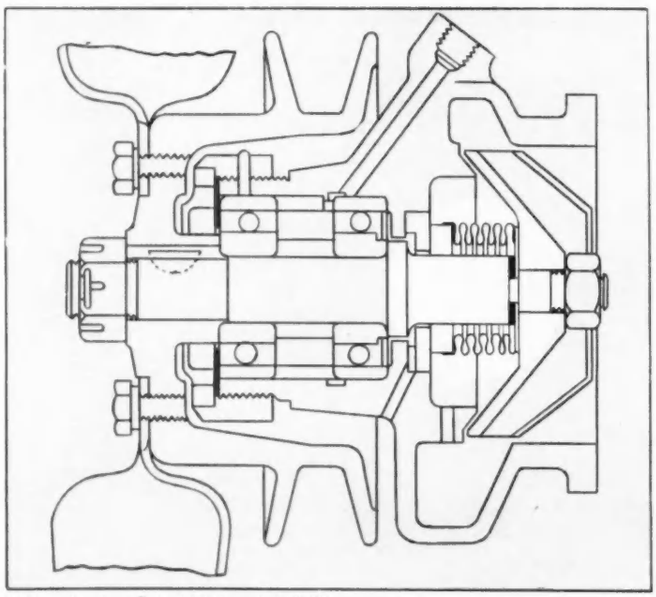
PACKLESS SHAFT SEALS

Photograph by courtesy of London Transport Executive

TEDDINGTON Shaft Seals are ideal for shafts running at speed. For example a 3½" dia. shaft running at 2000 R.P.M. in temperatures up to 300°F is quite normal. As peripheral speed of the rubbing surfaces is the deciding factor, they can be fitted to larger shafts running at lower speeds, or to smaller ones at high speeds. They will retain most liquids or vapours at pressures from 30-in. vacuum to 250 lbs. per sq. in., and are unaffected by continuous or intermittent running, or reversing.

. . . for effective sealing against most liquids and gases



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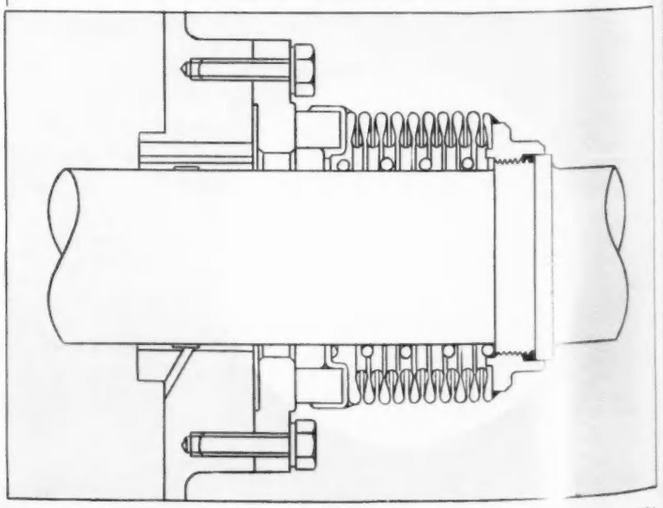
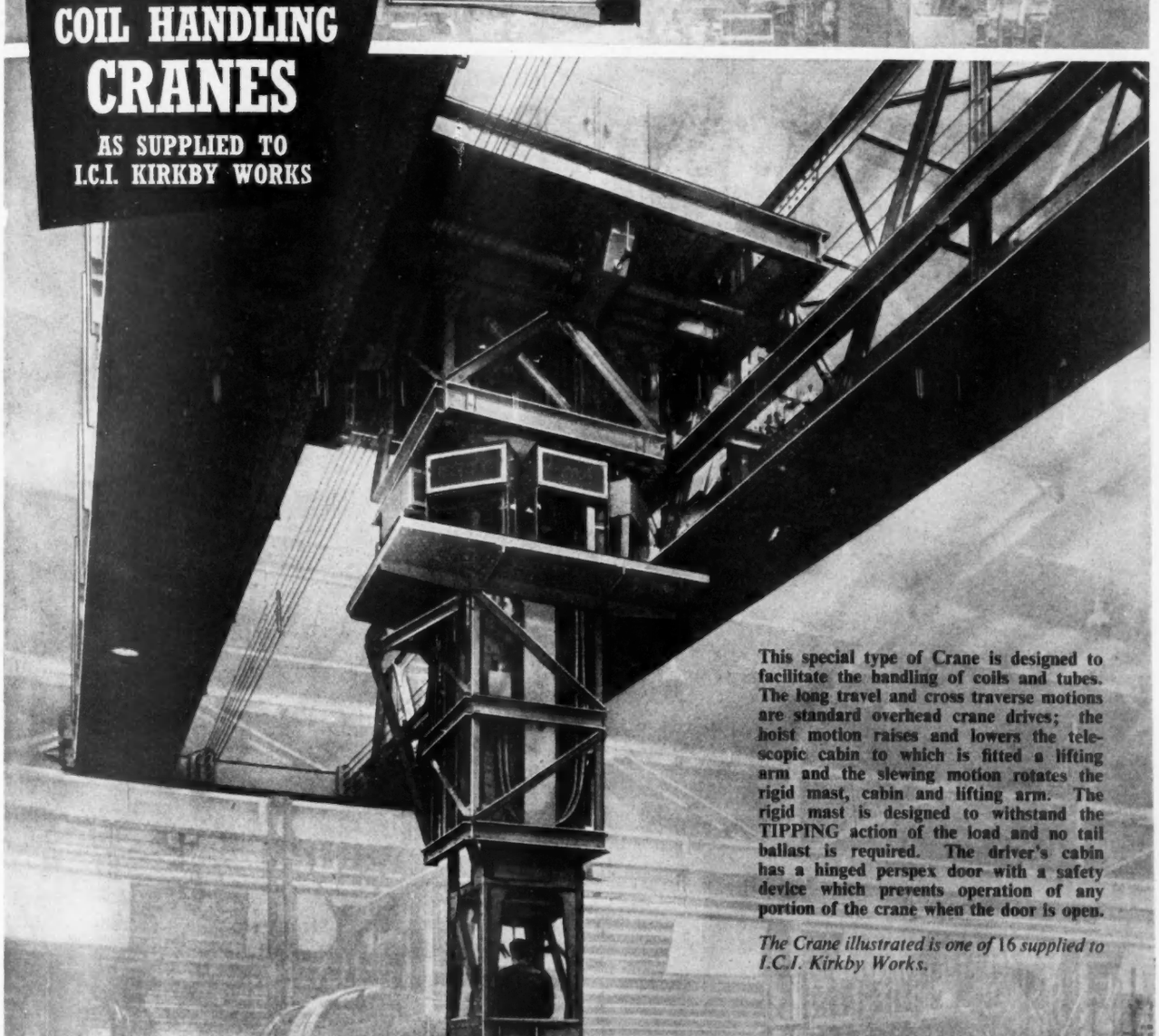


THE BRITISH THERMOSTAT CO. LTD., SUNBURY-ON-THAMES, MIDDLESEX. *Telephone: Sunbury-on-Thames 456*

TELEGRAMS: THERMOSTAT, SUNBURY-ON-THAMES, TELEX TELEX: 2-2742 TEDDCONTSNBR

RIGID MAST COIL HANDLING CRANES

AS SUPPLIED TO I.C.I. KIRKBY WORKS



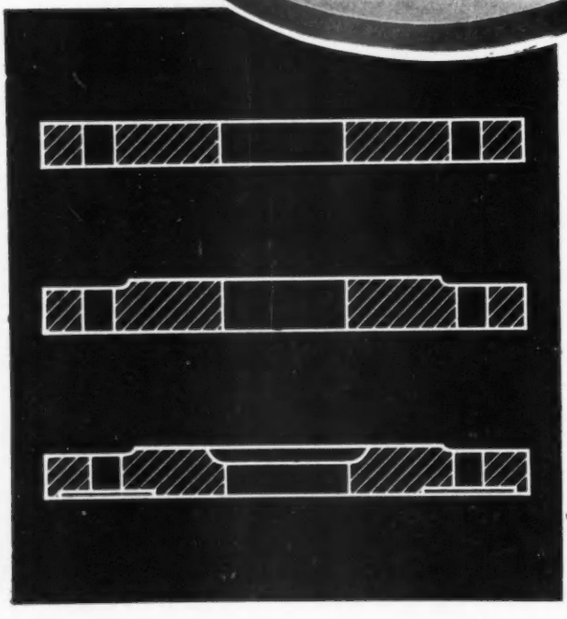
This special type of Crane is designed to facilitate the handling of coils and tubes. The long travel and cross traverse motions are standard overhead crane drives; the hoist motion raises and lowers the telescopic cabin to which is fitted a lifting arm and the slewing motion rotates the rigid mast, cabin and lifting arm. The rigid mast is designed to withstand the TIPPING action of the load and no tail ballast is required. The driver's cabin has a hinged perspex door with a safety device which prevents operation of any portion of the crane when the door is open.

The Crane illustrated is one of 16 *supplied to I.C.I. Kirkby Works.*

carruthers' cranes

J. H. CARRUTHERS & CO. LTD., GLASGOW, S.2. • London Office: Abford House, Wilton Road, Victoria, S.W.1

MILD STEEL PLATE TYPE flanges



We are able to supply, from stock, a full range of Standard Plate Type Mild Steel Flanges for pressures ranging from 51 p.s.i. to 450 p.s.i.

Non-standard Flanges manufactured to specification.

For details of standard dimensions write for List No. EG 905.

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No. 1 of a series of 6 advertisements

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STEEL CHAINS

FOR **CONVEYORS**

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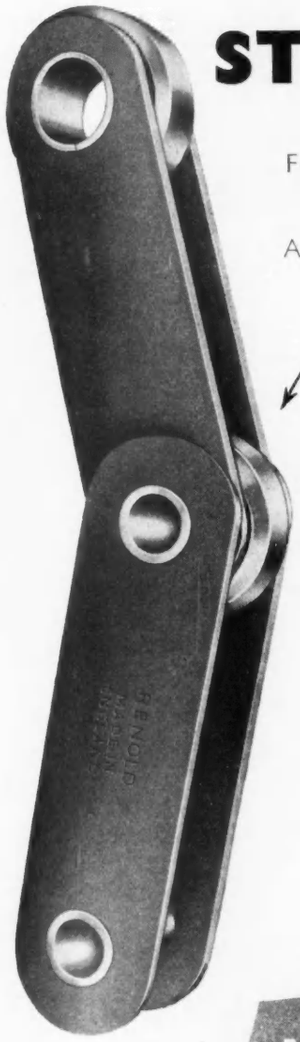
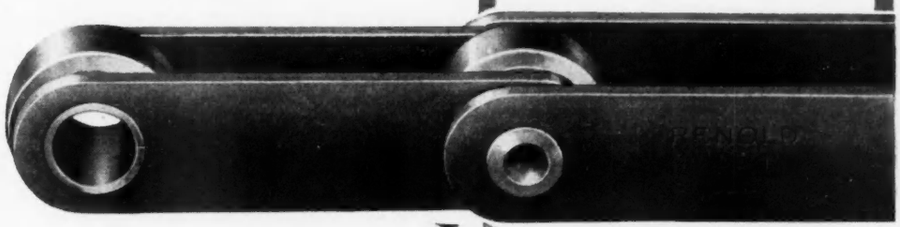


*HOLLOW BEARING PIN CHAIN



*SOLID BEARING PIN CHAIN

STOCK RANGE of chains and wheels up to 15,000 lb. breaking load. Range of attachments available, as illustrated, for fitting to basic chains at intervals as required.

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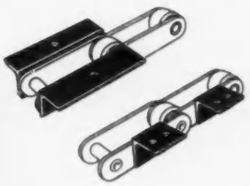
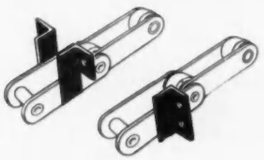
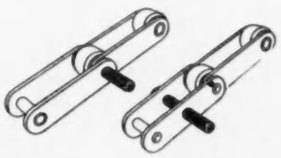


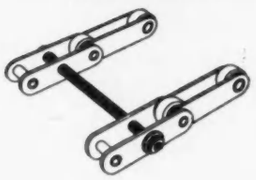
'F' ATTACHMENTS



SPIGOT PINS



STAY BARS



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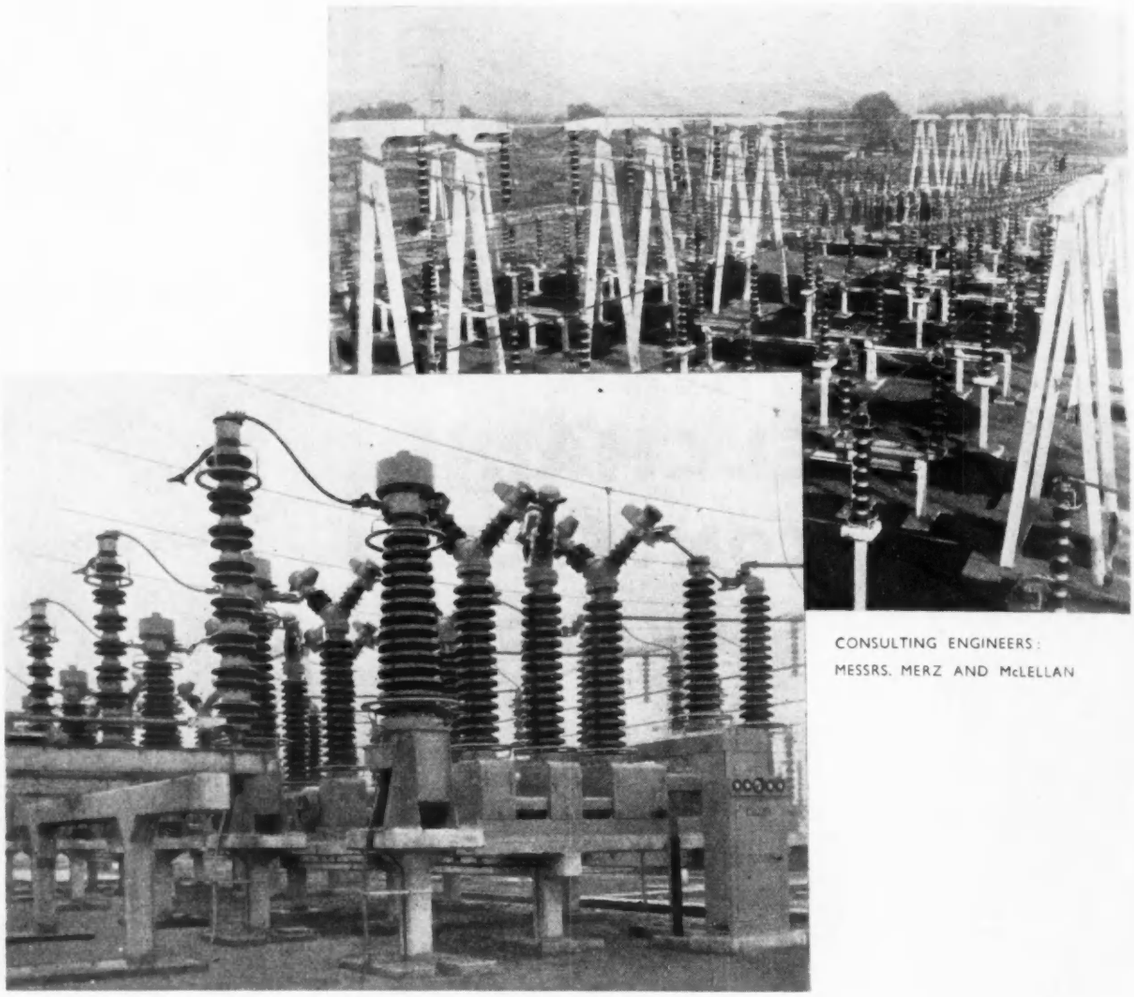
RENOLD CHAINS LIMITED MANCHESTER

Transmission and Conveying Chains, Wheels and Accessories for all mechanical purposes.



CONSULTING ENGINEERS:
MESSRS. MERZ AND McLELLAN

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Reyrolle 275-kV air-blast
circuit-breakers
now in commission
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news about COLES cranes

NEW CRANES TO LIFT 25 TONS AT 10 foot RADIUS

3 Newcomers to Coles range of mobiles

DESIGNED to lift a load of 25 tons at 10 ft. radius and incorporating several new features, are three important additions to the Coles range of mobile cranes. They are the self-propelled, lorry-mounted and rail versions of a new model—the 2710.

Fitted with a 30 ft. strut jib of lattice construction, the cranes have all the well-proved Coles features including diesel-electric transmission, with separate motors for the hoist, derrick and slew motions, and, in the case of the rail and self-propelled versions, for travelling too. The standard 30 ft. jib can be extended to a maximum length of 80 ft., which is capable of lifting 1½ tons over a radius of 60 ft.

This form of transmission ensures smooth handling with precise control at all times. Electro-mechanical brakes act automatically on the three motions of slew, hoist and derrick, the last two of which also have automatic self-resetting limit switches.

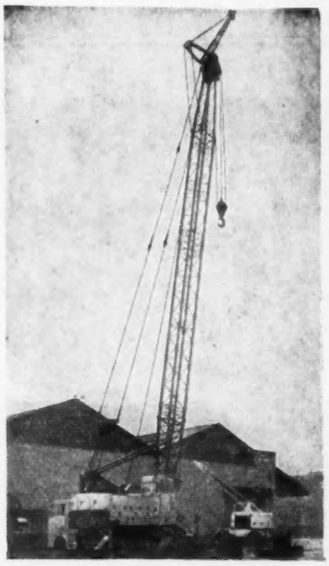
POWER UNITS

On the rail and self-propelled cranes a choice of two power units is offered—a Ford petrol engine giving 64 b.h.p. at 2200 r.p.m. or a Perkins diesel giving 65 b.h.p. at the same r.p.m. The lorry-mounted crane is fitted only with a Perkins engine. For travelling, this model uses an A.E.C. diesel engine of 150 h.p. at 1800 r.p.m., giving it a maximum road speed of 27·3 m.p.h.

Mounted on a Coles 6×4 crane carrier chassis, the L.2710 has power-assisted steering, a five-speed gearbox (with one reverse), an auxiliary gearbox and air pressure brakes on all wheels. A 6-wheel drive chassis can be supplied for cross-country operation.

A new feature on this model is a removable counterweight—an important consideration for countries which limit the weight of vehicles using public roads. The weight of the L.2710 can be reduced by 4 tons when the counterweight is removed.

The rail crane has eight single flange steel-tyred wheels and air pressure shoe brakes on all of them. Optional equipment includes spring buffers and derailing beams. On the self-propelled model the Coles automatic reversing mechanism on the steering gear is provided to give "correct" steering no matter what the position of the driving cab in relation to the wheels. Power-assisted steering can be supplied as optional equipment.



SAFE LOAD INDICATOR

An optional item for all models is a visual and audible safe load indicator, which warns the operator of any tendency to lift an unsafe load. Fly jibs can also be supplied as well as a single hook for faster hoisting speeds with light loads. The enclosed operator's cabs have safety glass opening windows and can be fitted with a fan or a heater according to climatic conditions.

The skill and experience which go into all Coles cranes are "built in" to the new models. Backed by sound service facilities the Coles 2710 is a worthy addition to the range.

Another 'Colossus' Triumph

–29 ton girder positioned in 14 minutes

Three 76 ft. steel bridge girders, one 29 tons and the others 22 tons each, were lifted from a transporter and accurately positioned on a new railway bridge structure within the space of 14 minutes each.

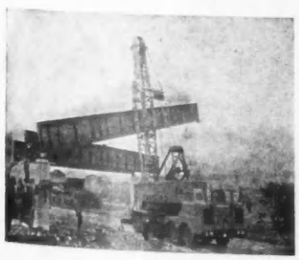
The crane that achieved this feat was the Coles "Colossus" 40-ton mobile crane—the largest mobile crane in the world—owned by Tarslag Ltd.

The job was carried out near Lynemouth

First stage of a big lift. The "Colossus" is seen unloading the three main bridge girders from the transporter which brought them to Woodhorn. Two of the girders weighed 22 tons, the other 29 tons.

Colliery in Northumberland and the bridge, which spans the main road between Newbiggin-by-the-Sea and Woodhorn, is to carry a double-track railway line from the new washing plant at Lynemouth Colliery to a main line connecting the other collieries.

The "Colossus" chosen for the job is the only fully mobile crane capable of handling such loads. During the 18 hours that the road was closed to traffic the three main girders and



The last of the three main girders of the Woodhorn bridge is lowered into position by the "Colossus". The precise control afforded by the Coles diesel-electric transmission system makes "pin-point" jobs such as this a comparatively simple matter.

54 concrete decking joists were positioned. In addition six approach span girders weighing up to 6 tons were placed in position while the road was in full use.

The girders, fabricated by Dorman, Long & Co., Ltd., were brought to the site on a road transporter. All were lifted by the "Colossus" and positioned accurately on the bridge piers in single operations.

Consulting engineers are Maunsell, Posford & Pavry, Ltd., and the contractors are Holloway Bros. (London), Ltd.

It's Coles again for Babcock & Wilcox

THE internationally famous engineering company of Babcock and Wilcox is at present using 50 Coles mobile cranes on projects in various parts of the world.

Recently they ordered a further two cranes—one for service in South Africa, the other for India. One of the many jobs on which Babcock and Wilcox, Ltd., are engaged at the moment is the extension of the Catalazzi Power Station in Turkey. The project is costing £3½ million and our picture shows a Coles S.1710 in action there.

"Mobile Handling in the Iron & Steel Industry"

Many of the largest iron and steel producers have already discovered the benefits to be gained by using mobile cranes in the mills. Coles cranes are fitted with grabs and magnets as well as hooks, making a vital contribution to the ever-increasing output of this important industry.

If you would like more information on the part Coles cranes can play in one of Britain's basic industries write for our new catalogue, which is full of information on this important subject.

◀▶

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Mechanical Materials Handling Dept.
Sunderland, England.

Tel.: Sunderland 56281 (10 lines). Grams: Steel Sunderland.

◀▶

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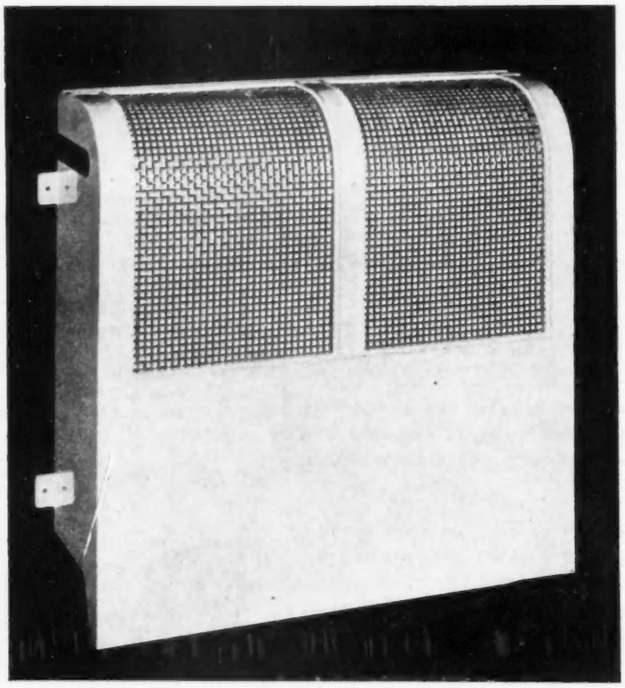

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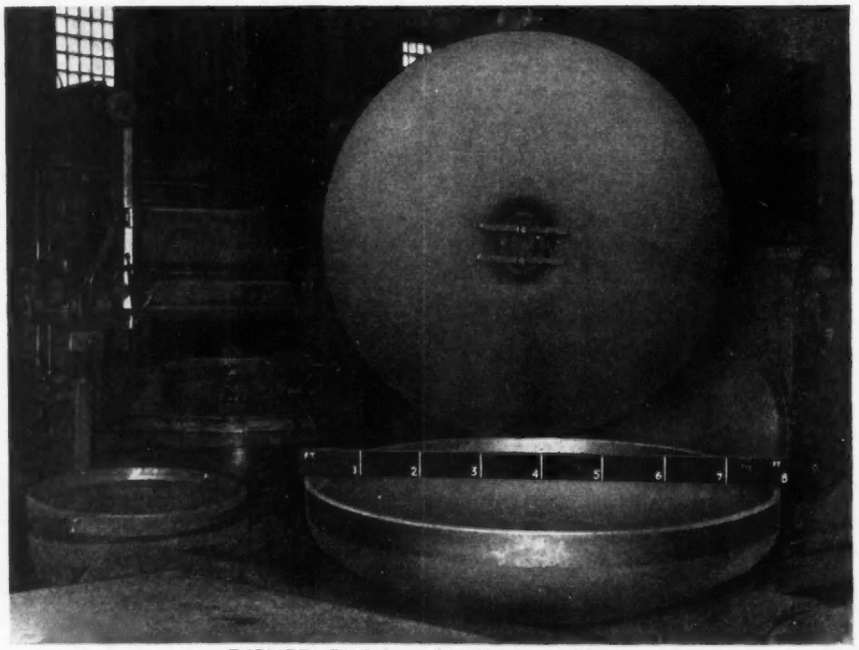

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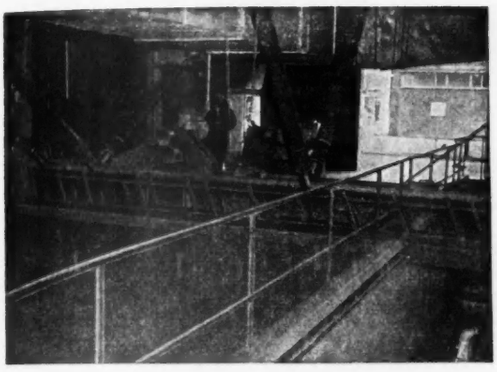

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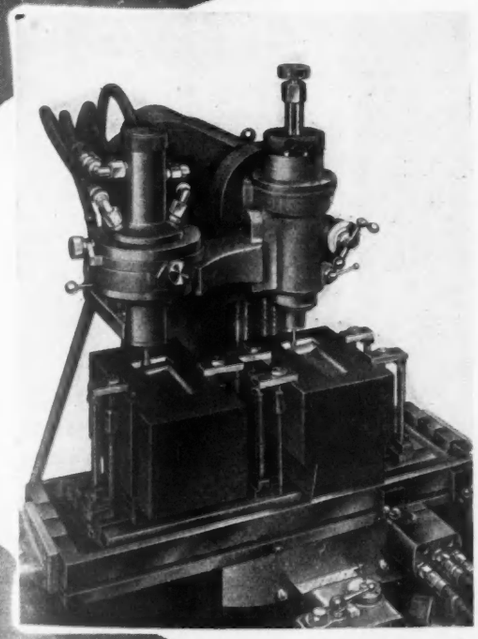

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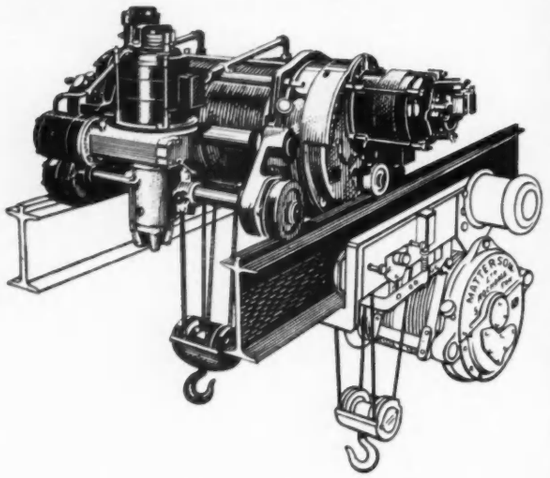

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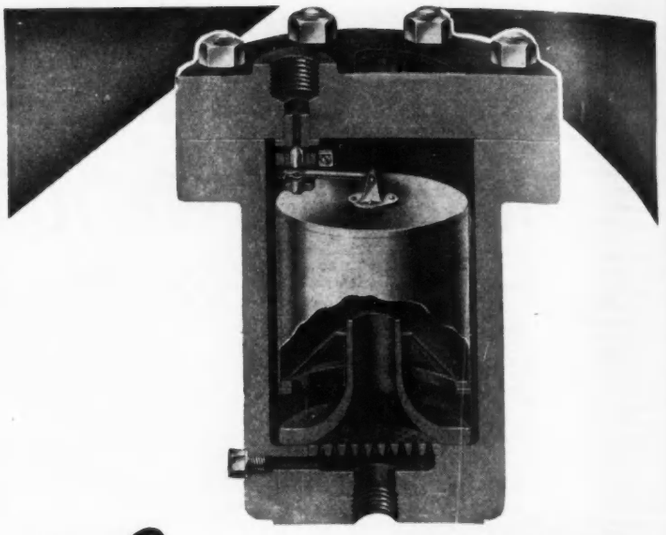

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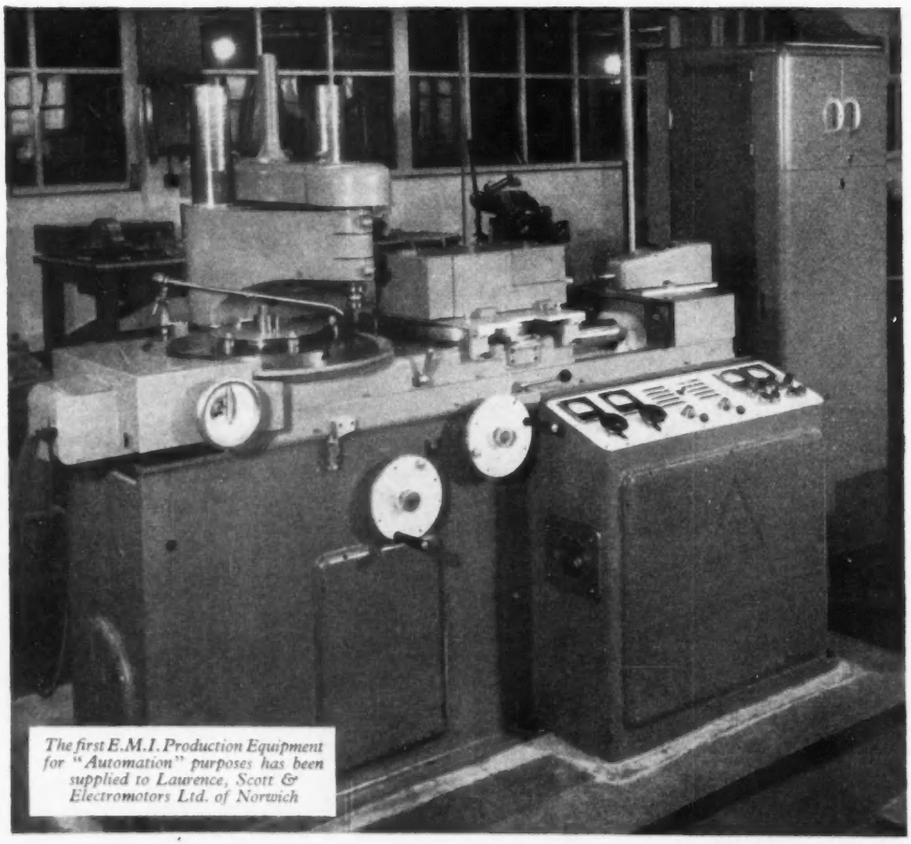

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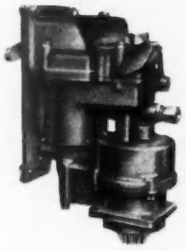

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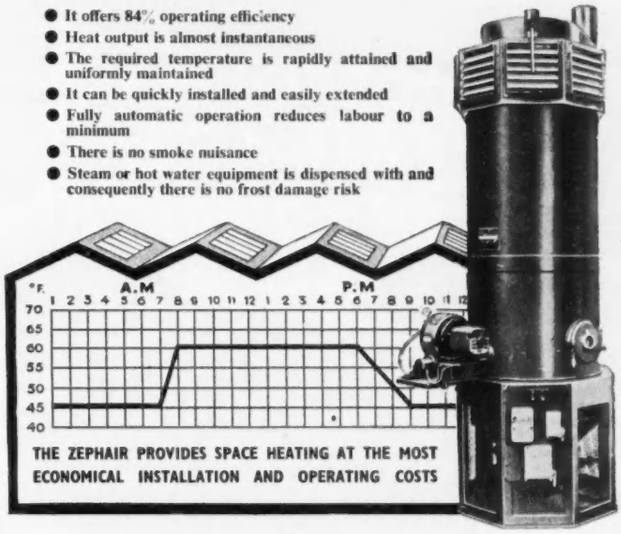

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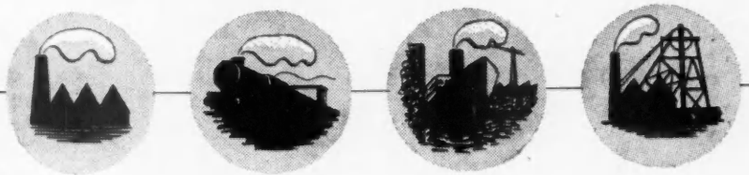

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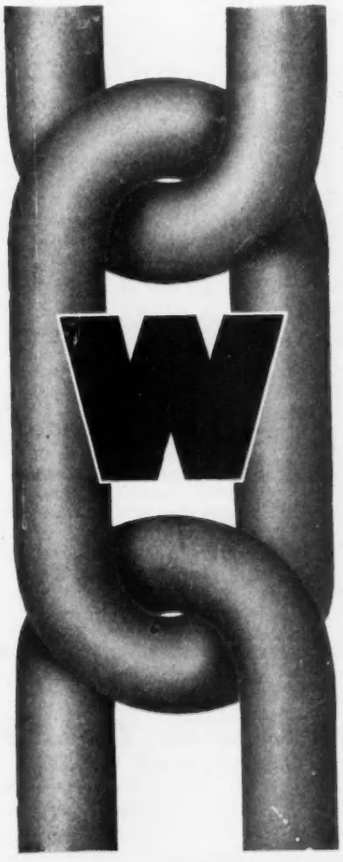

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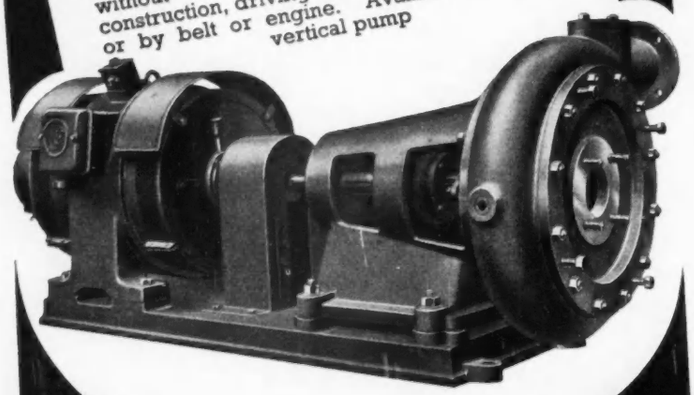

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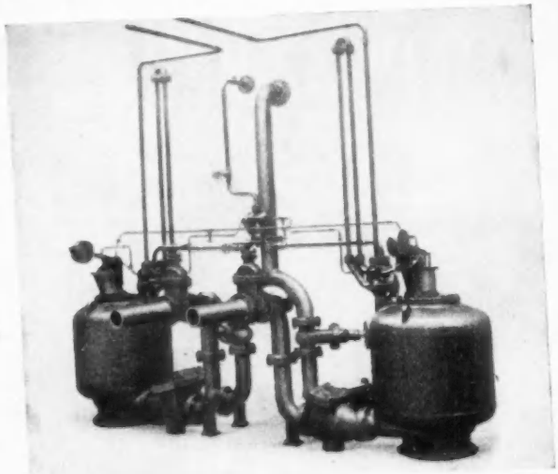

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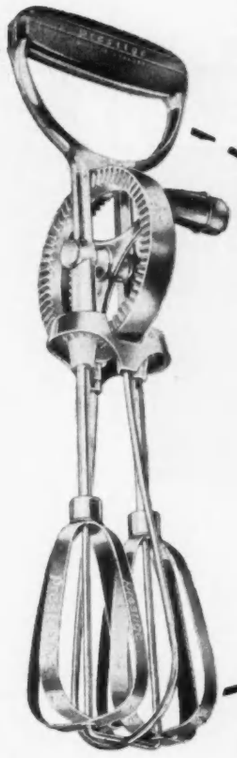

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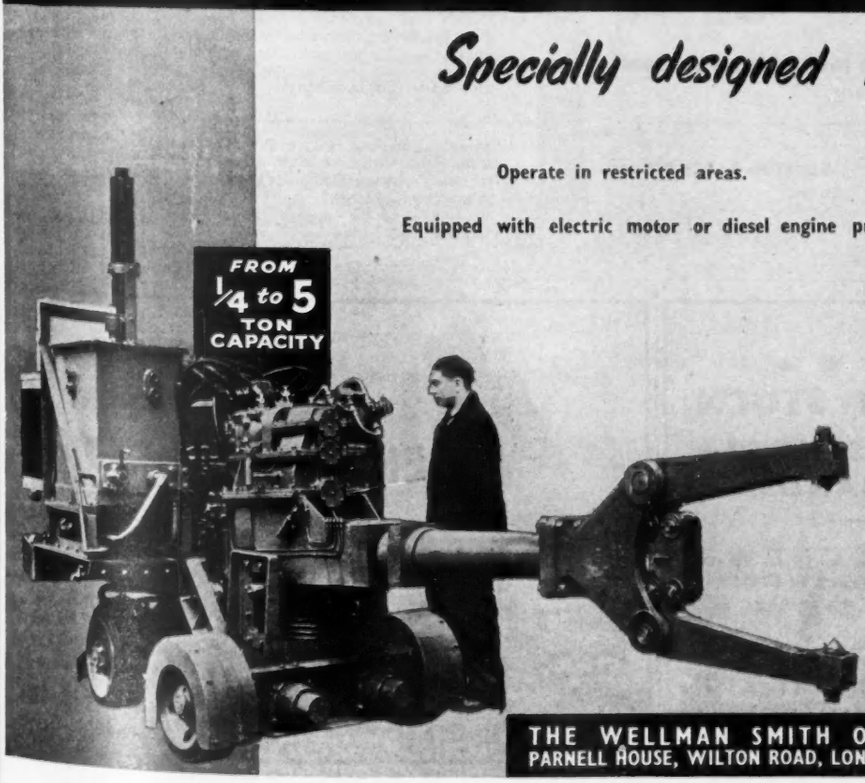

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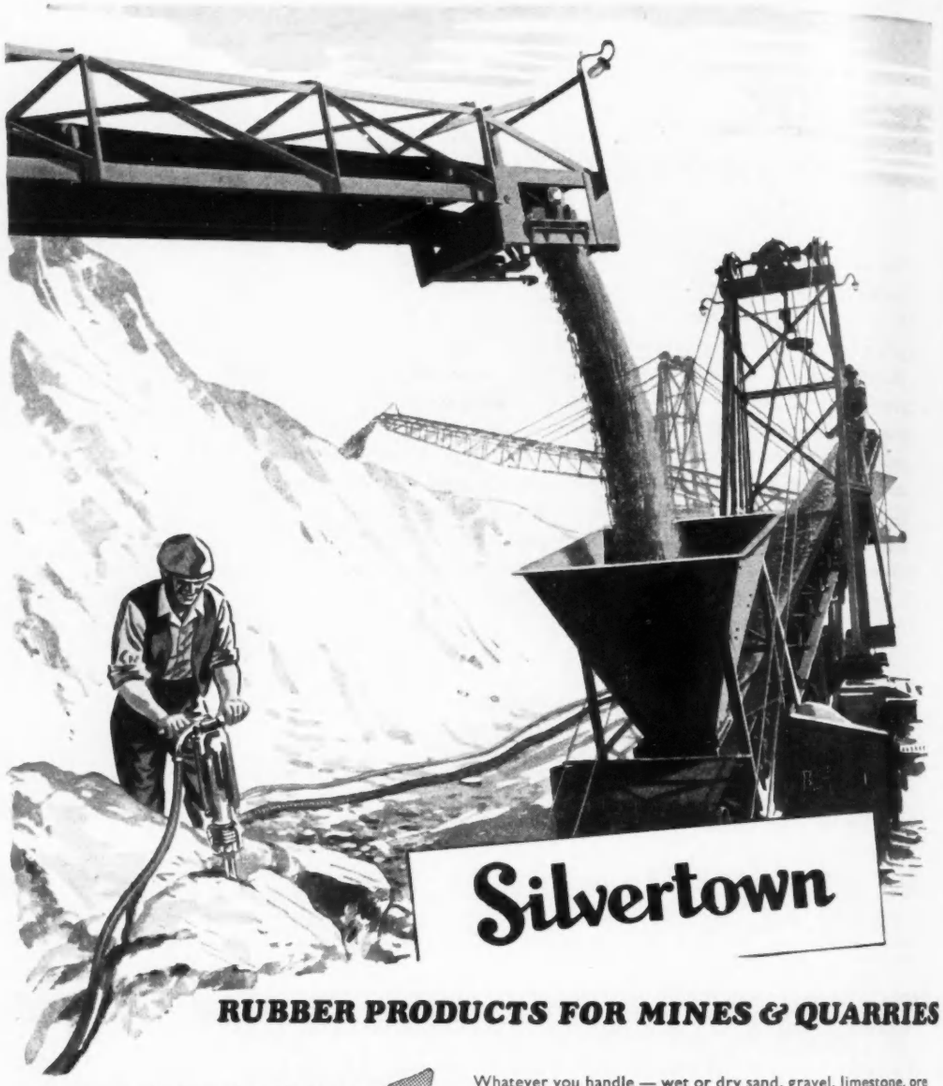

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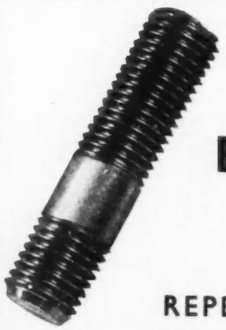

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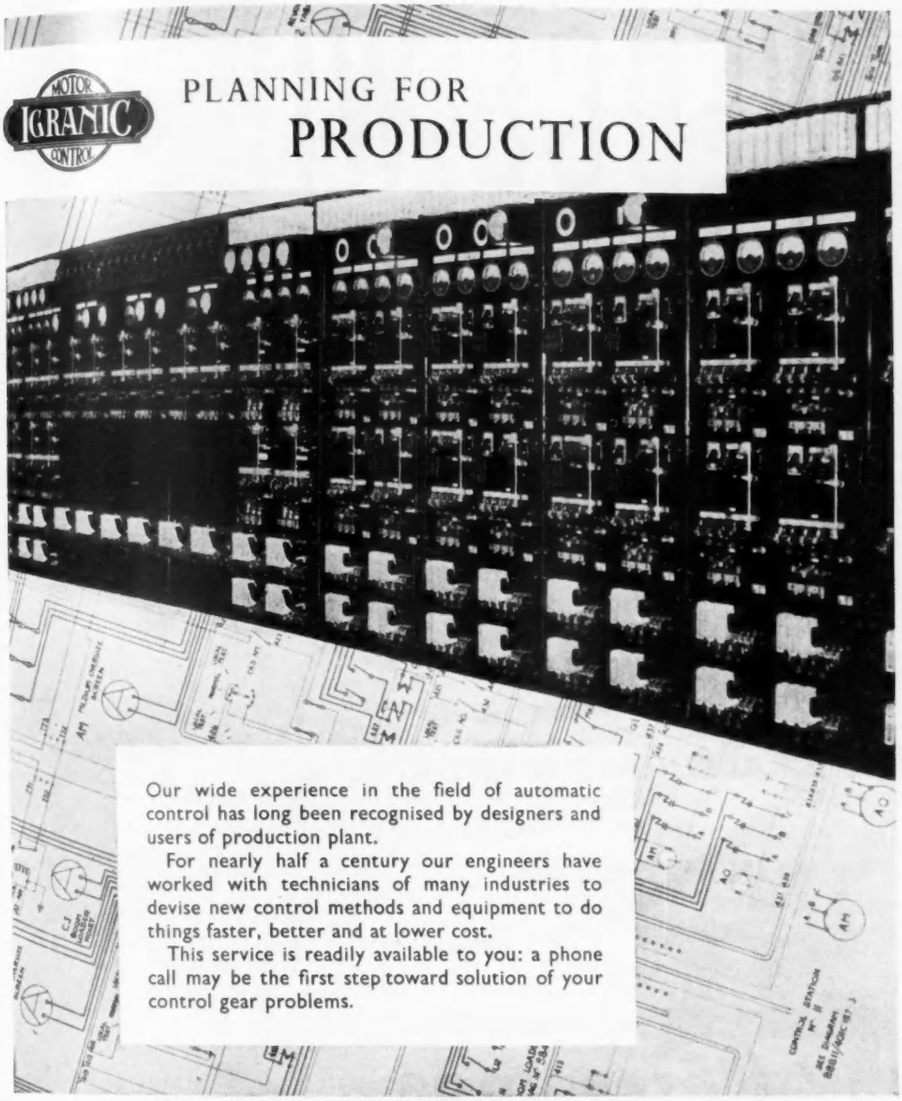

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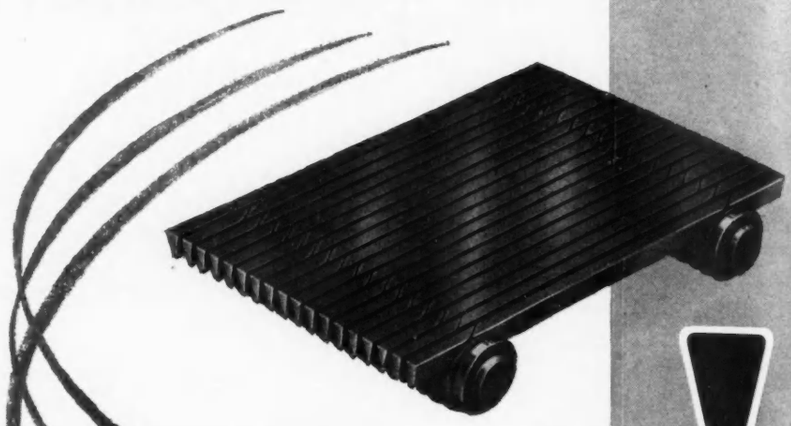

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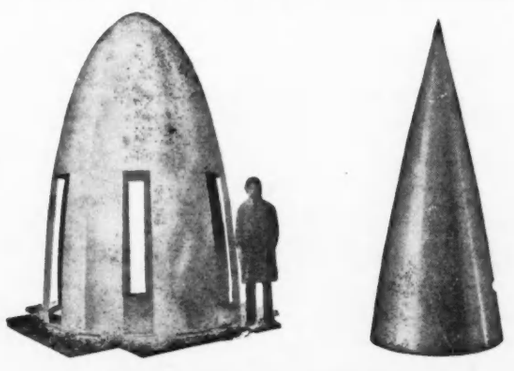

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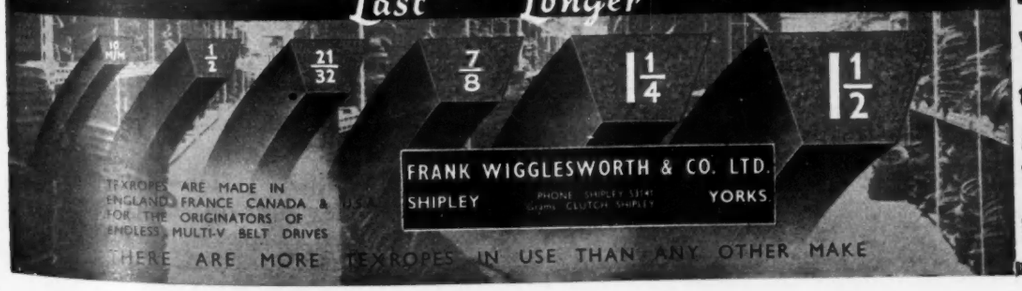

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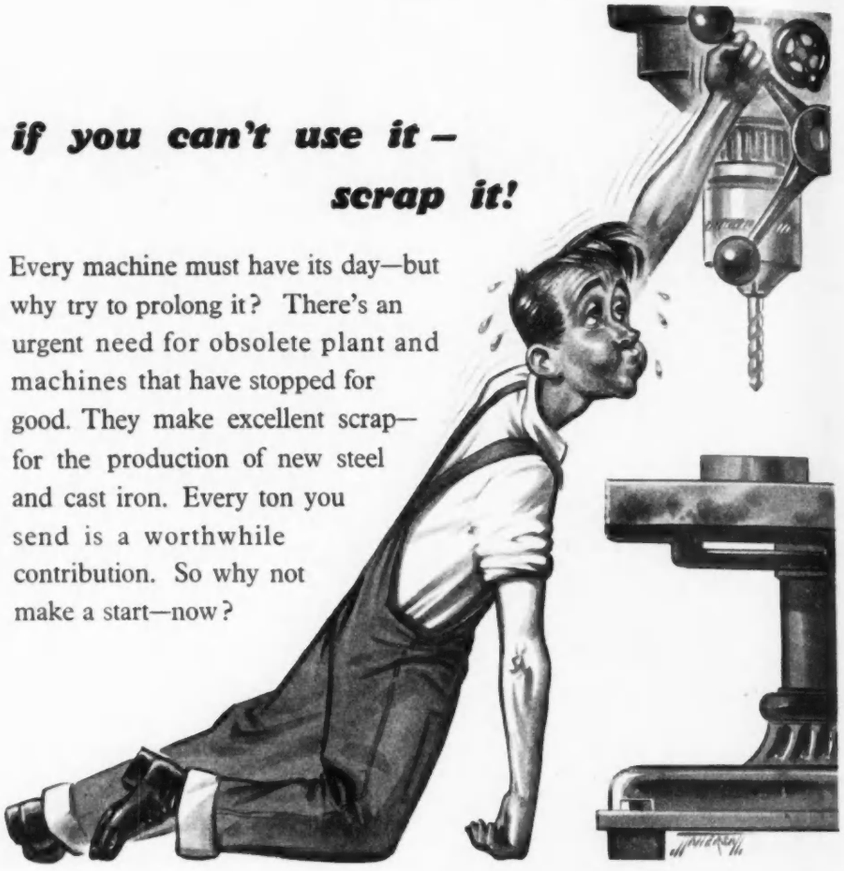

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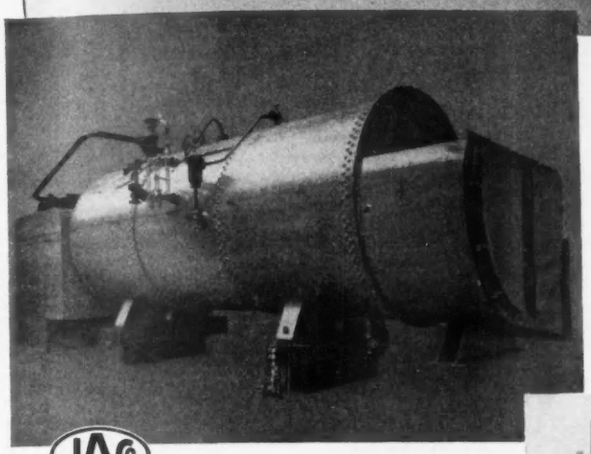

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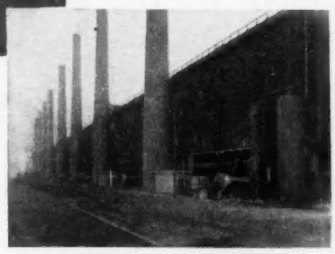

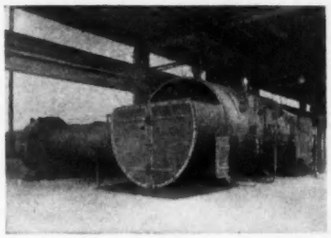

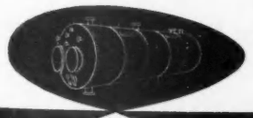

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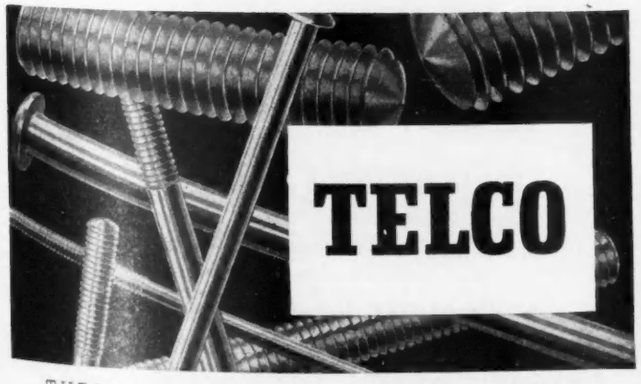

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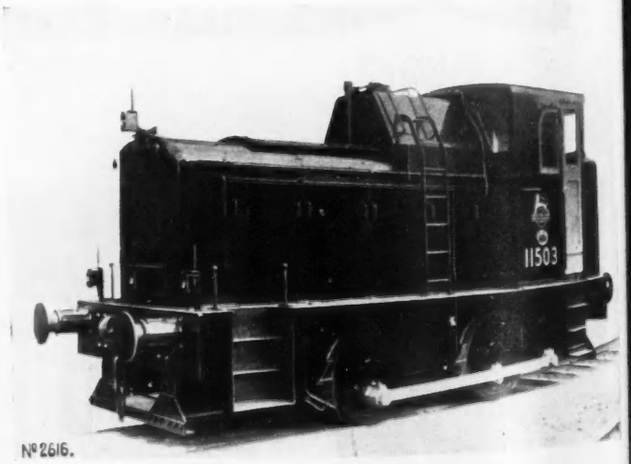

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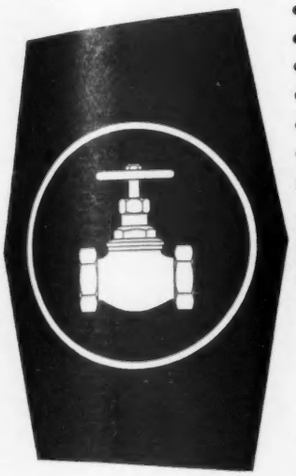

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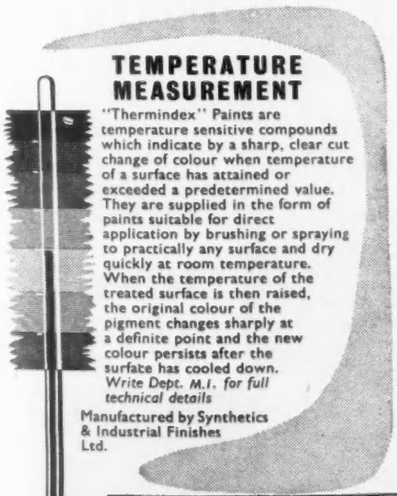

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Classified Advertisements continued from Page 8

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YOUNG TECHNICAL SALES REPRESENTATIVES required for immediate appointment by large rubber manufacturing Company. Candidates may have to undergo special training in the Company's factories before being allocated a territory. Preference given to men who have served an engineering apprenticeship or hold a degree in mechanical engineering. Car provided. Good salary and excellent prospects. Pension scheme.—Apply GROUP PERSONNEL MANAGER, BRITISH TYRE & RUBBER CO., LTD., HERGA HOUSE, VINCENT SQUARE, LONDON, S.W.1. K 56

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THE BRITISH OXYGEN GASES LIMITED require the services of a
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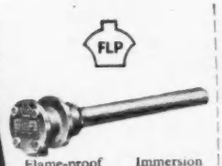

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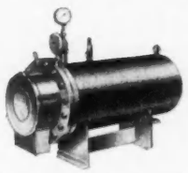
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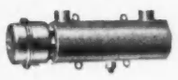
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IMPORTANT APPOINTMENTS FOR ENGINEERS.

POWERS-SAMAS ACCOUNTING MACHINES, LTD. (one of the Vickers Group of Companies) is expanding the resources of its Research Division for the development of electronic data processing equipment, punched-card machines and allied devices. A new Research Laboratory is under construction at Caterham, Surrey—and until its completion the staff appointed will work at existing establishments in Croydon and Crayford, Kent.

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1. Engineers with graduate or equivalent qualifications for research and development work on small complex mechanisms associated with punched card accounting systems.

2. Engineers with a sound technical background and ability to analyse complex mechanisms and to effect practical and economic improvement.

Applications, with details of experience and qualifications, should be sent to THE PERSONNEL MANAGER, POWERS-SAMAS ACCOUNTING MACHINES, LTD., CROYDON. G 629

Classified Advertisements continued on Page **94**

PLANNING ENGINEER.

ALLEY & MACLELLAN (POLMADIE) LTD., GLASGOW, S.2, require the services of a fully qualified

PLANNING ENGINEER. He must have first class experience in modern production methods in medium/heavy machine shops and be capable of working on own initiative.

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This is a key position in the organisation and for the right man will provide an excellent opportunity for promotion to a higher position in the company.

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GEORGE WIMPEY AND CO., LTD.,

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REINFORCED CONCRETE ENGINEER-DESIGNERS

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DETAILERS

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SENIOR DRAUGHTSMAN required for makers of Machine Tools and Sheet Metal Machines.—Apply with age, experience, salary, etc. to F. J. EDWARDS, LTD., 359, EUSTON ROAD, LONDON, N.W.1. K 40

YOUNG MECHANICAL ENGINEER with degree or equivalent qualifications is required in the Plant Engineering Division of The British Iron and Steel Research Association, in London. Wide interests. Apply in writing, stating salary required to M.E.8, THE PERSONNEL OFFICER, B.I.S.R.A., 11, PARK LANE, LONDON, W.1. K 45

ENGINEER REQUIRED, used to the manufacture of Oil Filter Elements, both paper and felt and wire type.—Please reply in full details to: CROSLAND FILTERS, LTD., LATHAM STREET WORKS, BULWELL, NOTTINGHAM. K 46

A successful career in the Steel Industry can result from a good start in the British Iron and Steel Research Association. Applications are invited from

KEEN YOUNG MECHANICAL ENGINEERS APPROACHING H.N.C. standard. Attendance at day classes allowed. Work centred in London (Battersea).—Apply in writing to THE PERSONNEL OFFICER, B.I.S.R.A., 11, PARK LANE, LONDON, W.1, quoting M.E.5. K 47

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THIS ANNOUNCEMENT WILL BE OF INTEREST TO YOUNG ENGINEERS

especially if you are looking for a post which offers the scope to fully utilise your abilities. The Clayton Dewandre Co. Ltd., of Lincoln offers interesting careers as

DESIGNER DRAUGHTSMEN

to young men with a knowledge of mechanical engineering and/or heat transfer practice and some Drawing Office experience.

Here are some of the advantages we offer:—Five-day week; non-contributory pension scheme; regular contacts with our Customers and Suppliers, and a brand new Drawing Office with modern equipment. Full sports facilities are also available.

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Rocket Division of Armstrong Siddeley Motors has really good vacancies for

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JUNIOR ENGINEERS for design of O.H. Transmission Lines in London office of large Company. Applicants must be graduates, or possess H.N.C. in Civil or Electrical engineering. Write stating age, qualifications, experience and salary required to BOX E.G. 563 c/o 191, GRESHAM HOUSE, E.C.2. J 997

CONSTRUCTIONAL ENGINEER required on the London Staff of well established Food Manufacturers. A.M.I.C.E. or equivalent, preferably with experience of large scale industrial constructions in steel and reinforced concrete, site works and site supervision. Accustomed to working with Architects, Local Authorities and Building Contractors. Candidates should be aged 28-32, possessing initiative and energy. Prospects of advancement in a growing organisation. Pension Scheme.—Write giving details of age, education, experience and salary required to BOX J 972., Offices of ENGINEERING.

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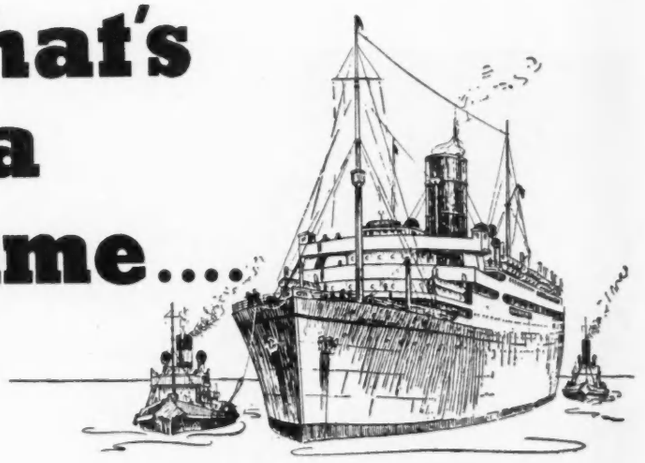

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Degree in Mechanical Engineering or equivalent.
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THE PROPRIETOR OF BRITISH PATENT NO. 601572 for "TWIN EXPANSION TURBINE FOR PRODUCTION OF LOW TEMPERATURES," desires to enter into negotiations with a firm or firms for the sale of the patent or for the grant of licences thereunder. Further particulars may be obtained from MARKS & CLERK, 57 & 58, LINCOLN'S INN FIELDS, LONDON, W.C.2. J 969

THE PROPRIETOR OF PATENT NO. 594598 for "VALVE FOR FIRE PROTECTIVE SYSTEM" desires to secure commercial exploitation by Licence or otherwise in the United Kingdom.—Replies to HASELTINE LAKE & CO., 28, SOUTHAMPTON BUILDINGS, CHANCERY LANE, LONDON, W.C.2. K 12

THE PROPRIETORS OF BRITISH PATENT NO. 681687 for "IMPROVEMENTS IN OR RELATING TO BAYONET FASTENINGS," desire to enter into negotiations with a firm or firms for the sale of the patent or for the grant of licences thereunder. Further particulars may be obtained from MARKS & CLERK, 57 and 58, LINCOLN'S INN FIELDS, LONDON, W.C.2. K 34

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Classified Advertisements continued on Page 96

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A well-balanced tool with automatic, spring-loaded action to give a wide range of impressions
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Light, perfectly balanced, with hardened and ground points, available in both engineers' and pocket types.
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LANG 15½ IN. HEAVY DUTY S.S. & S.C. LATHE, all-geared head, single saddles, sine bar type, taper turning attach., height of centres 15½ in., dist. bet. centres 15 ft., swing over saddles 20 in., 12 forward speeds, 8.5-403 r.p.m., 4 reverse speeds, 16-338 r.p.m., h.p. of motor 20.

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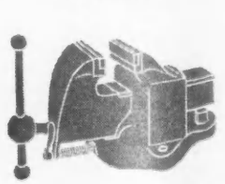

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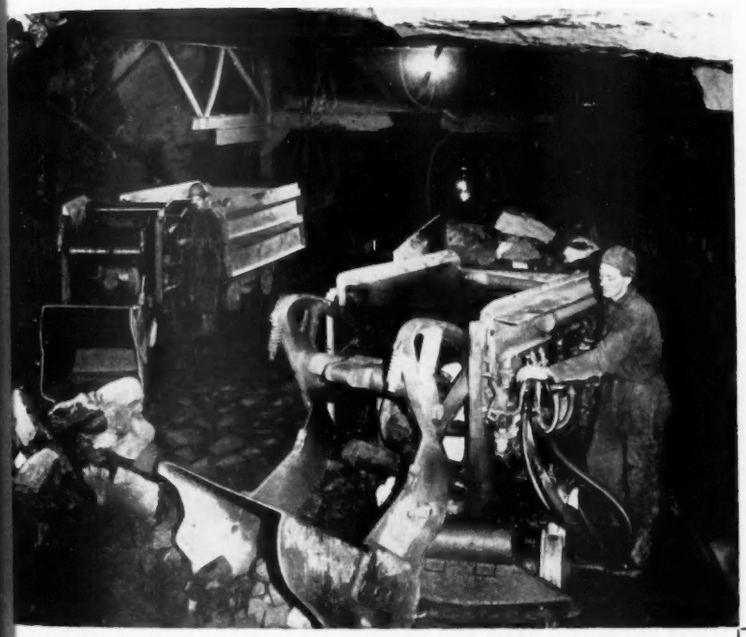

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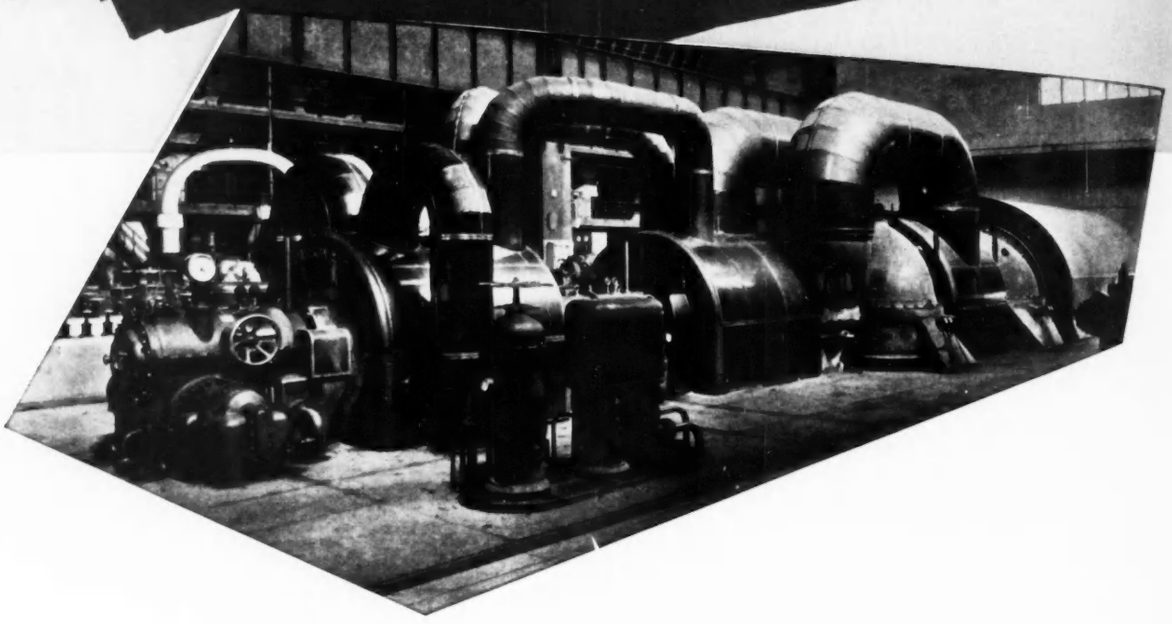

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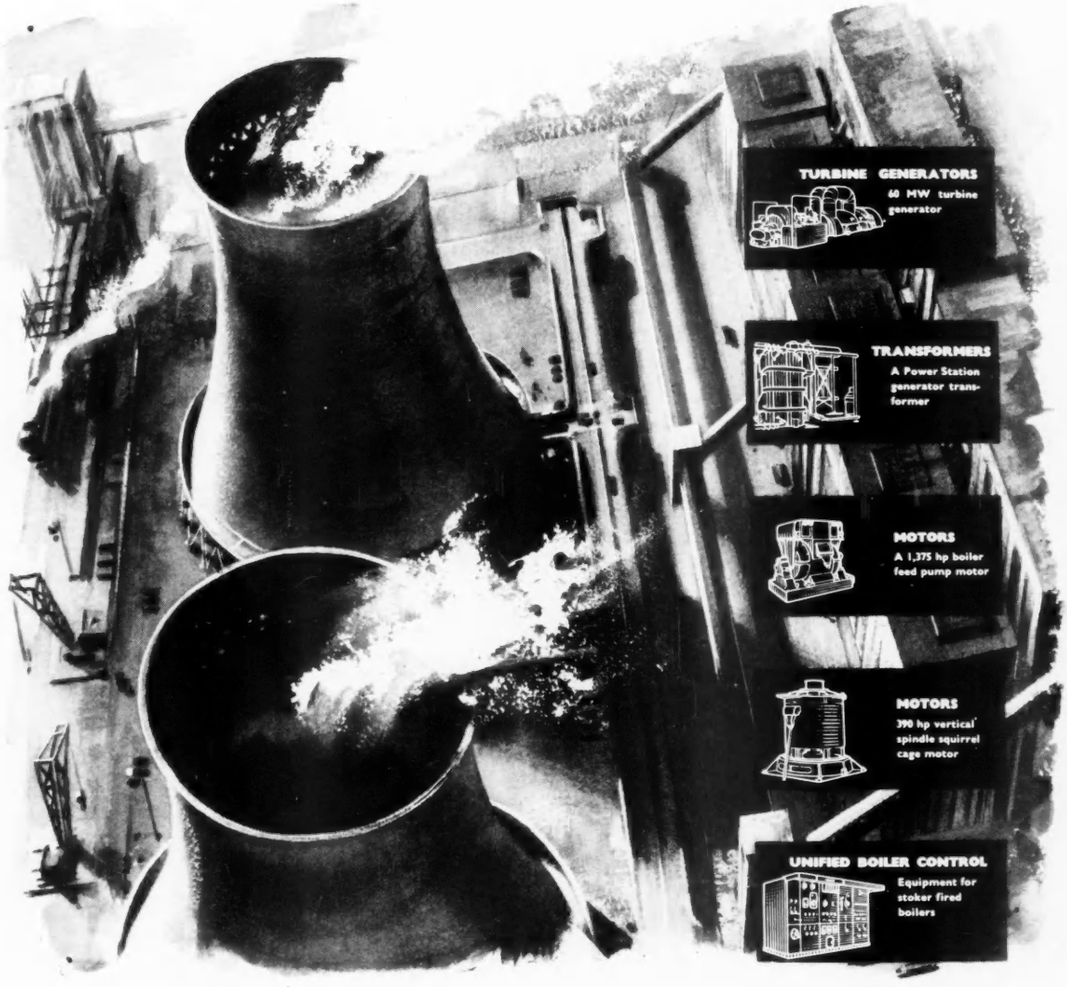

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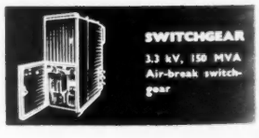

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